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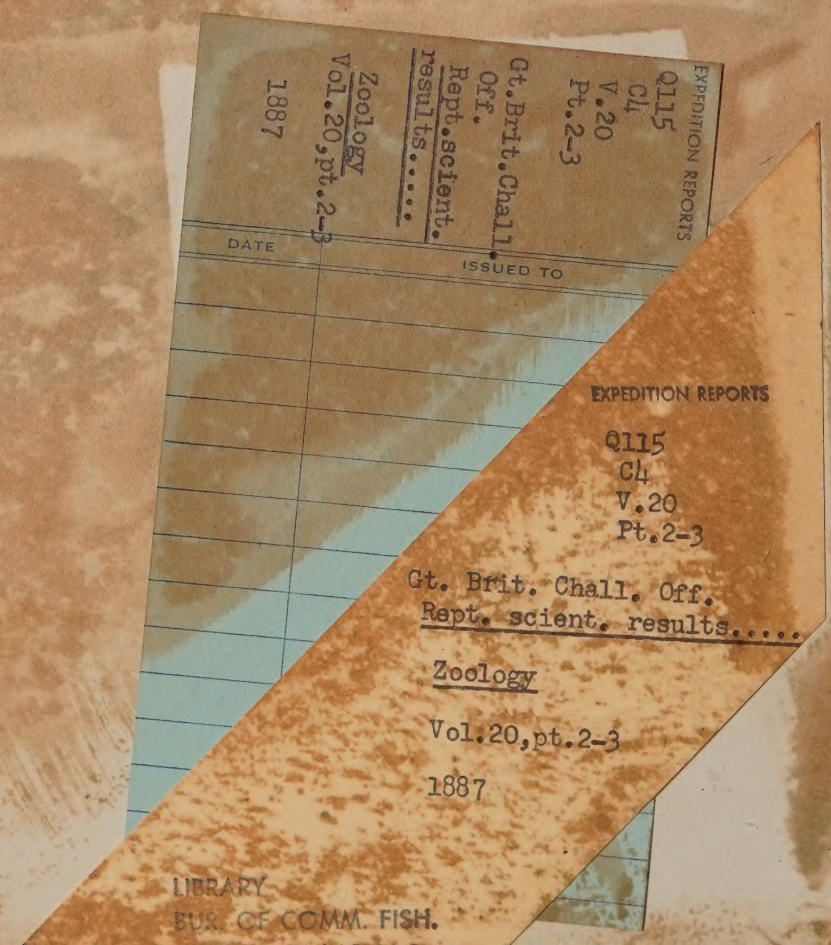

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REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND THE LATE

CAPTAIN FRANK TOURLE THOMSON, R.N.

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ZOOLOGY—VOL. XX.

PART LXI.—REPORT ON THE MYZOSTOMIDA—SUPPLEMENT

BY DR. L. VON GRAFF

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EDITORIAL NOTE.

This Part is a Supplementary Report on the Myzostomida by Dr. L. von Graff, Professor of Zoology in the University of Graz, Austria, and contains descriptions of seven new species, and also references to the literature of the group which has appeared since the publication of the First Part of the Report. It contains sixteen pages and four plates.

The First Part of Dr. L. von Graff's Report forms Part XXVII. of the Zoological Series of Reports.

The Manuscript was received on 10th March 1887.

John Murray.

Challenger Office, 32 Queen Street,
Edinburgh, 22*nd July* 1887.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the MYZOSTOMIDA collected during the Voyage of H.M.S. Challenger during the years 1873–76. By Dr. L. VON GRAFF, Professor of Zoology and Comparative Anatomy in the University of Graz, Austria.

SUPPLEMENT.

SINCE the publication of my Report on the Myzostomida collected during the voyage of H.M.S. Challenger, I have received from my friend Dr. P. Herbert Carpenter, F.R.S., a number of specimens, of which the following pages contain a Supplementary Account. The collection includes seven new forms, besides fourteen species previously described. I shall follow the enumeration given in my Report, and append the new species to the previous list; in the case of each species references are also given to the literature which has appeared since the publication of my Report. I must refrain from entering upon any discussion of the numerous interesting questions which have been raised by recent researches on the Myzostomida,[1] and this I do the more willingly, since my friend and pupil Dr. von Wagner has undertaken the task of working out, on the basis of thorough anatomical investigation, the generic classification of the species, which, including those about to be discussed, now number seventy-eight.

Of the forms included in Carpenter's collection, three are in such an imperfect state of preservation that no adequate diagnosis can be given. One of these was dredged by Dr. J. Anderson, F.R.S., at Padau Bay in the Mergui Archipelago, on *Antedon milberti*, Valenc. sp. The second was found in the same locality, either on

[1] A complete bibliography will be found in the large memoir by Fridtjof Nansen, Bidrag til Myzostomernes Anatomi og Histologi, Bergen, 1885, 4to, 80 pp., 9 pls. In addition to this must be mentioned the contemporary memoir by F. von Wagner, Das Nervensystem von Myzostoma (F. S. Leuckart), Graz, 1886, 8vo, 52 pp., 1 pl.

Antedon milberti or *Antedon comata*, P. H. C. On neither of these Crinoids have Myzostomida been hitherto described. The third specimen was obtained from *Antedon incisa*, P. H. C. (Station 170, Chall. Exp.), and presents some resemblance in form, thickness, and translucent marginal zone to *Myzostoma brevipes* (Report, No. 16). Its diameter measures 2·2 mm.; the ten marginal cirri are about 0·14 mm. in length; the colour of the body is dirty yellow. The back bears five pairs of low but sharply angled radial ridges. All the other specimens admitted of identification.

2. *Myzostoma longipes*, Graff.

Myzostoma longipes, Graff, Bull. Mus. Comp. Zoöl. Cambridge, vol. xi. p. 126, 1883.

6. *Myzostoma alatum*, Graff.

Myzostoma alatum, Graff, Proc. Roy. Soc. Edin., vol. xii. p. 379, 1884.

This *Myzostoma*, found on *Antedon phalangium*, Müll. sp., off Carthagena in 80 fathoms of water (by H.M.S. "Porcupine," 1870), is a species new to the Mediterranean fauna. In size (3·5 mm. in longitudinal diameter), colour, and form, it exactly resembles the specimen figured in the Report (pl. i.), except that on the back the insertions of the parapodia appear as sharply projecting bosses, on the apex of which the base of the hook could be seen as a small tubercle. The thin marginal portion reveals without any treatment, but better still after saturating with glycerine, the very abundant, wide, and thickly crowded intestinal branches, which like the ova extend close to the margin of the disc.

The animal was situated between the mouth and anal-tube of its host, in part astride of the anal tube, and with its pharynx turned towards the oral margin of the *Antedon*. It was very firmly attached.[1]

10. *Myzostoma glabrum*, F. S. Leuckart.

Myzostoma glabrum, Beard, Mittheil. Zool. Stat. Neapel, Leipzig, vol. v., 1885.
„ „ Nansen, Bidrag til Myzostomernes Anatomi og Histologi, Bergen, 1885.
„ „ Wagner, Das Nervensystem von Myzostoma, Graz, 1886.

A new host for this species is *Antedon petasus* (Düb. and Kor.), from which Carpenter sent me two specimens (0·6 and 1·5 mm. in diameter).

11. *Myzostoma gigas*, Lütken (Pl. II. fig. 4).

Myzostoma gigas, Graff, Proc. Roy. Soc. Edin., vol. xii. p. 378, 1884.
„ „ Nansen, *Op. cit.*

Of two specimens from *Antedon eschrichti*, Müll. sp., from Station 48 of the Challenger Expedition, the one measured 1·75 mm., the other 2 mm. in longitudinal diameter, and

[1] Station 13 of the "Porcupine" Expedition of 1870, where this species was also obtained, is in the Atlantic, off Mondego on the Portuguese Coast, and not off Duncansby Head as given on p. 32 of the Report.

both exactly corresponded in form and colour with figs. 7 and 8 on pl. ii. of the Report, except that there was here no trace of the dorsal median depression.

The larger of the two individuals was doubly deformed; for in the first place the first left parapodium was reduced to a very small prominence, and secondly it bore, between the seventh and eighth left cirri, a small supernumerary cirrus (fig. 4, *c*).

12. *Myzostoma testudo*, Graff.

Myzostoma testudo, Graff, Bull. Mus. Comp. Zoöl. Cambridge, vol. xi. p. 128, 1883.

15. *Myzostoma marginatum*, Graff.

Myzostoma marginatum, Graff, *Ibid.*

16. *Myzostoma brevipes*, Graff.

Myzostoma brevipes, Graff, *Ibid.*, p. 127.

17. *Myzostoma carpenteri*, Graff.

Myzostoma carpenteri, Graff, Proc. Roy. Soc. Edin., vol. xii. p. 380, 1884.
„ „ Nansen, *Op. cit.*

Since the Report was published Dr. Carpenter has discovered that the host of this species, *Antedon sarsii* of the Scandinavian naturalists (=*Alectro dentata*, Say), is identical with the *Asterias tenella* of Retzius; and it must therefore be known in future as *Antedon tenella*, Retzius sp.

18. *Myzostoma areolatum*, Graff.

Myzostoma areolatum, Graff, Bull. Mus. Comp. Zoöl. Cambridge, vol. xi. p. 127, 1883.

20. *Myzostoma coriaceum*, Graff.

In the collection of the K. zool. Genootschap in Amsterdam, I found on a black *Actinometra* (n. sp.), from the Moluccas, a specimen of the above. It measured 8 mm. in diameter, and agreed in every respect with the specimen described in the Report (pl. xi.). The latter was found, however, on an *Antedon*[1] (*Antedon insignis*), the

[1] The generic difference in the host of *Myzostoma coriaceum* is a further proof of the correctness of a criticism made by Dr. P. Herbert Carpenter, who writes to me as follows :—"I notice that you say on page 21 (Report) 'where one species infests more that one host, the latter are always closely allied.' This does not always hold good, as the genus is sometimes different, *e.g.*, *Myz. echinus*, *elegans*, *carinatum*, *inflator*, and *costatum*, while *Ant. eschrichtii* and *Ant. carinata*, on which *Myz. gigas* is found, are very different indeed; so also *Ant. hageni* and *Ant. spinifera* (hosts of *Myz. agassizi*). I fancy that in many cases, *e.g.*, *Myz. tenuispinum*, it is rather a question of locality."

name of which has been meanwhile altered by Bell in the "Alert" Report[1] to *Antedon loveni*.

22. *Myzostoma pulvinar*, Graff.

Myzostoma pulvinar, Graff, Proc. Roy. Soc. Edin., vol. xii. p. 379, 1884.

26. *Myzostoma pictum*, Graff.

Myzostoma pictum, Graff, Bull. Mus. Comp. Zoöl. Cambridge, vol. xi. p. 128, 1883.

28. *Myzostoma cirriferum*, F. S. Leuckart.

Myzostoma cirriferum, Graff, Proc. Roy. Soc. Edin., vol. xii. pp. 378, 380, 1884.
„ „ Beard, Mittheil. Zool. Stat. Neapel, Leipzig, vol. v., 1885.
„ „ Nansen, *Op. cit.*
„ „ Wagner, *Op. cit.*

P. H. Carpenter's collection includes numerous specimens of this species, from 0·2 mm. in length to fully grown forms. They were obtained partly from *Antedon petasus*, D. and K. sp. (Cattegat), partly from *Antedon rosacea* (from Torquay, Arran, Oban, Isle of Man, Keumaes Bay, north coast of Anglesea). Those from the last two localities were dredged by the Liverpool Marine Biological Committee, and among them there is one form with a supernumerary cirrus between the seventh and eighth left cirri, and another which is remarkable because of its all but perfect circular contour (longitudinal diameter 1·52 mm., transverse 1·5 mm.).

29. *Myzostoma crenatum*, Graff,

Myzostoma crenatum, Graff, Bull. Mus. Comp. Zoöl. Cambridge, vol. xi. p. 129, 1883.

31. *Myzostoma vastum*, Graff.

Myzostoma vastum, Graff, *Ibid.*

32. *Myzostoma agassizii*, Graff.

Myzostoma agassizii, Graff, *Ibid.*

35. *Myzostoma elongatum*, Graff.

A badly preserved specimen, 2·5 mm. in length, lying loose in the spirit with *Antedon occulta*, *Antedon similis*, and *Antedon tuberculata*, all new species, from Station 174, Challenger Expedition, to the south-west of Fiji.

[1] Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H.M.S. "Alert," 1881–82, p. 158. London, 1884.

37. *Myzostoma dentatum*, Graff.

A specimen measuring 2·7 mm. in length, lying loose in a vessel along with *Actinometra solaris*, *Actinometra bennetti*, and five species of *Antedon*, from the Molluccas (K. zool. Genootschap, Amsterdam).

38. *Myzostoma fimbriatum*, Graff.

Two specimens found on *Antedon quadrata*, P. H. C., from Station 48, Challenger Expedition. Both were almost circular, the one measuring 2 mm., the other 2·3 mm. in diameter. The cirri of the latter measured 0·17 mm. in length, so that the length given in the Report (p. 49) must have referred to much contracted cirri (*cf.* also the figure). The habitat of the above specimens has removed any doubt as to whether the host was *Antedon eschrichtii* or *Antedon quadrata*.

39. *Myzostoma excisum*, Graff.

Myzostoma excisum, Graff, Bull. Mus. Comp. Zoöl. Cambridge, vol. xi. p. 128, 1883.

40. *Myzostoma irregulare*, Graff.

Myzostoma irregulare, Graff, *Ibid.*, p. 130.

41. *Myzostoma caribbeanum*, Graff.

Myzostoma caribbeanum, Graff, *Ibid.*, p. 130.

42. *Myzostoma rotundum*, Graff.

Myzostoma rotundum, Graff, *Ibid.*, p. 130.

43. *Myzostoma oblongum*, Graff.

Myzostoma oblongum, Graff, *Ibid.*, p. 130.

44. *Myzostoma abundans*, Graff.

Myzostoma abundans, Graff, *Ibid.*, p. 131.

45. *Myzostoma elegans*, Graff.

Myzostoma elegans, Graff, *Ibid.*, p. 130.

47. *Myzostoma cornutum*, Graff.

On *Antedon alternata*, P. H. C., from Station 236, Challenger Expedition, there was found a dirty yellow translucent specimen of a small *Myzostoma* with damaged posterior extremity, but agreeing in the character of its cirri, suckers, and parapodia with *Myzostoma cornutum* (Das Genus Myzostoma, Taf. x.). It was apparently a very young form, only 1·2 mm. in length, and the difference in age may also account for the almost circular outline of the body. *Antedon alternata* is a new host for this species.

49. *Myzostoma fissum*, Graff (Pl. I. figs. 5, 6).

From two additional specimens of the above species I am now able to amplify my previous description, which was based on a much contracted form.

Both these new specimens measured, including the caudal appendages, about 4·5 mm. in length, and were of a yellowish-brown colour. On the one (figs. 5, 6) the first and second pair of caudal appendages (I, II) were considerably shorter than the third, and the dorsal ridge exhibited a sharp edge, and a less wavy outline than the specimen figured in the Report (pl. iv.). The other specimen occupied, as regards its caudal appendages, a median position between the two forms above mentioned, and the dorsal ridge was only slightly defined.

In both, however, it was distinctly seen that the figure of the ridges given in the Report was doubly at fault. In the first place the ridges have a radial course on the disc, the anterior running forwards, the posterior backwards to the margin; and secondly, similar ribs extend also from the body disc to the dorsal surface of the caudal appendages.

The figures show the ventral surface and exhibit the position of the mouth (*m*), the strong parapodia (*p*), and the very slightly developed suctorial pits (*s*).

These specimens were found lying loose in spirit with *Antedon occulta*, *Antedon similis*, and *Antedon tuberculata*, all new species from Station 174, Challenger Expedition, to the south-west of Fiji.

51. *Myzostoma quadrifilum*, Graff.

This specimen was found on *Antedon microdiscus*, Bell, from Station 186, Challenger Expedition, off Cape York. It was dark brown in colour, and measured, without caudal appendages, 0·8 mm. in length and 0·64 in breadth, like the form represented in the Report on pl. iv. fig. 3. There is, however, this difference between the two, that in this form the *external* caudal appendages are much more strongly developed than the inner pair. They are as long as the body; the thick basal portion measuring 0·5 mm., and the terminal

filament 0·3 mm. in length. Here again the cirri of the *first* pair are the longest (0·2 mm.), the others measuring only about 0·12 mm. Since the species exhibits manifold variations (see Report, pp. 56, 57), I do not regard these differences as sufficient for the establishment of a new species.

Antedon microdiscus is a new host for this *Myzostoma*.

Another specimen, from *Antedon bidentata*, P. H. C., from Station 186 (Cape York), Challenger Expedition, exactly resembled in form that figured in the Report, pl. iv. fig. 4. The body was 0·8 mm. in length, and outside the base of the third pair of feet the slightly raised male genital papilla was very distinctly recognisable.

52. *Myzostoma quadricaudatum*, Graff.

A specimen from *Antedon fluctuans*, P. H. C., dredged in the Torres Strait from a depth of 10 fathoms by H.M.S. "Alert." The body measured 0·83 mm. in length up to the bifurcation, the maximum breadth was 0·78 mm., and the length of the largest caudal appendage was 0·44 mm., the two posterior being slightly unequal.

54. *Myzostoma bicaudatum*, Graff.

Myzostoma bicaudatum, Graff, Bull. Mus. Comp. Zoöl. Cambridge, vol xi. p. 131, 1883.

55. *Myzostoma filicauda*, Graff.

Myzostoma filicauda, Graff, *Ibid.*, p. 132.

57. *Myzostoma carinatum*, Graff.

Myzostoma carinatum, Graff, *Ibid.*, p. 131.

In a vessel containing *Actinometra solaris*, *Actinometra bennetti* and five species of *Antedon* from the Moluccas (collection of the K. zool. Genootschap, Amsterdam), there was a *Myzostoma*, 2·8 mm. in length, with lateral margins much folded towards the ventral surface, but closely resembling *Myzostoma carinatum* (Report, pl. ii.) both in colour and in the dorsal markings. The cirri, which occur very abundantly on the margin, are *relatively* shorter and thicker, and have a maximum length of 0·2 mm. The median dorsal ridge is especially prominent, and the paired laterals are less wavy than in the above form, and start with their full breadth from the median pad instead of beginning as fine ridges and becoming gradually broader. These differences are not however sufficient for specific distinction.

63. *Myzostoma cysticolum*, Graff.

Myzostoma cysticolum, Graff, Bull. Mus. Comp. Zoöl. Cambridge, vol. xi. p. 132, 1883.

65. *Myzostoma willemoesii*, Graff (Pl. III. figs. 5, 6).

The collection before me includes a deformed fragment of arm, and a deformed pinnule of *Antedon flexilis*, P. H. C., from Station 192, Challenger Expedition, in the Arafura Sea. The former contains a hermaphrodite *Myzostoma* which I regard as new, and which is described below as *Myzostoma beardi* (No. 77); while the pinnule deformity arises from the presence of *Myzostoma willemoesii*.

The deformity has a close resemblance to those represented on pl. xiv. of the Report. The segments are broadened, shaped like a roof, and united into a capsule which encloses the roof-shaped widened ambulacral groove. But while in the former the *whole* pinnule shares in the deformity, the point of the pinnule (α) remains in this case unchanged and free. And while formerly I always found (Report, p. 71) in each deformity a pair of *Myzostomata*—a larger female and a dwarf male—the present deformity contains only a single male. This measures 1·4 mm. in length, and 1 mm. in maximum breadth. It corresponds with that figured in the Report, pl. xiv. fig. 5, except that the suckers are less conspicuous, being only partially recognisable with the lens, and that the ten cirri are very irregularly developed. In the former the cirri were not indeed of equal length, but in the specimen before me the differences are much more striking, and the length varies from 0·03 to 0·13 mm., as can be distinctly seen by an inspection of fig. 6 where the cirri (III–VII) of the left margin are represented. After saturation with glycerine it was seen that the restricted stomach branches leave a free marginal zone, 0·1 mm in breadth.

66. *Myzostoma inflator*, Graff.

Myzostoma inflator, Graff, Bull. Mus. Comp. Zoöl. Cambridge, vol xi. p. 133, 1883.

67. *Myzostoma murrayi*, Graff.

Myzostoma murrayi, Graff, *Ibid.*

68. *Stelechopus hyocrini*, Graff.

The host of this species is *Hyocrinus bethellianus*, Wyv. Thompson.

69. *Myzostoma cirripedium*, Graff.

Myzostoma cirripedium, Graff, Trans. Linn. Soc. Lond. (Zool.), ser. 2, vol. i. pp. 444–445, fig. 19, 1885.

This species, found on *Metacrinus rotundus*, P. H. C., is closely allied to *Myzostoma wyville-thomsoni* (No. 30), but differs from all forms hitherto described in the possession of parapodial cirri.

70. *Myzostoma giganteum*, Nansen.

Myzostoma giganteum, Nansen, Bidrag til Myzostomernes Anatomi og Histologi, Bergen, 1885.

Very like *Myzostoma gigas* (No. 11), found on *Antedon prolixa*, Sladen.[1]

71. *Myzostoma graffi*, Nansen.

Myzostoma graffi, Nansen, *Op. cit.*

Resembling *Myzostoma marginatum* (No. 15), found on *Antedon prolixa*, *Sladen*.

72. *Myzostoma nanseni*, n. sp. (Pl. II. figs. 2, 3).

This beautiful *Myzostoma*, which I have named in honour of Mr. Fridtjof Nansen, has a close resemblance to the *Myzostoma folium* described in the Report. The single specimen before me measures 8 mm. in length, and in its uncontracted state must have been about 3 mm. in breadth, so that it is not so elongated as *Myzostoma folium*. It differs from the latter, further, at first sight, in the absence of a distinctly defined marginal zone. The body disc, which is about 1 mm. in thickness, seems to thin off imperceptibly into the finely notched margin. The marginal notches are besides more individualised and pointed, not blunt as in the species above referred to. A flat longitudinal groove marks the middle line of the ventral surface, while the median dorsal line projects conspicuously only in the region of the very strongly developed pharynx (*ph*).

The parapodial insertions are marked on the back by five pairs of lateral elevations. The colour is a uniform dirty brown with a slight reddish tinge.

The mouth is situated not far from the anterior end, but the cloacal papilla (*cl*) lies at the commencement of the last quarter of the body. The parapodia (*p*) are very strong, and disposed at equal intervals in two longitudinal rows between the mouth and cloacal papilla. The round suckers (*s*) are very slightly developed, and hardly recognisable with a lens.

Found lying loose in spirit with a black *Actinometra* (n. sp.) and several other Comatulæ from Moluccas (K. zool. Genootschap, Amsterdam).

[1] This species was referred to by Nansen as the *Antedon celtica* of Marenzeller and of Sladen; but Dr. P. H. Carpenter, who has received specimens of it from Nansen, identifies it with *Antedon prolixa*, Sladen.

73. *Myzostoma longicirrum*, n. sp. (Pl. I. fig. 4).

In the circular form of the body, in the crenate character of the sharply defined and hyaline marginal fringe, as also in the topographic distribution of the organs, this new species resembles *Mysostoma crenatum* (Report, pl. vii.). The well-developed parapodia (*p*) lie halfway between the margin and the middle of the body, the mouth (*m*) is almost in the same line, and the comparatively small round suckers (*s*) are situated halfway between the insertions of the parapodia and the margin of the body. The most striking feature in this form, the disc of which has a diameter of about 1·25 mm., is the development of the cirri, of which the first to third and eighth to tenth pairs appear extraordinarily elongated, but not uniformly, while the shortened fourth to seventh pairs are of equal length, as the following measurements show :—

I.	pair of cirri	measures	0·86 mm.
II.	,,	,,	0·84 ,,
III.	,,	,,	0·49 ,,
IV.–VII.	,,	,,	0·23 ,,
VIII.	,,	,,	0·57 ,,
IX.	,,	,,	0·78 ,,
X.	,,	,,	0·73 ,,

There are furthermore slight differences between the cirri of the same pair, especially in the tenth.

The single specimen was much damaged, and the figure given is thus to a large extent a restoration.

It was found on *Actinometra parvicirra*, Müll. sp., from Samboangan (Challenger Expedition).

74. *Myzostoma ambiguum*, n. sp. (Pl. II. fig. 1).

This form recalls at first sight *Myzostoma antennatum* (Report, pl. viii.), but differs from it not inconspicuously in this, that both posteriorly and anteriorly there are two pairs of elongated cirri. The anterior and posterior ends of the body are so like one another, that it is necessary to examine it by transmitted light, in order to distinguish the two extremities. It measures 1·4 mm. in length, and the maximum breadth is 1·1 mm. The dimensions of the cirri can be given only approximately, since many of them are torn away (as indicated in the restoration by the lighter lines), while others are too much twisted to admit of exact measurement. The short cirri of the third to eighth pairs have a maximum length of 0·3 mm., the first pair 0·54 mm., the second 0·7 mm., the ninth 0·8 mm., the tenth 1 mm. The colour is a bright yellowish-brown. The stomach branches (*i*) and ovaries leave only a narrow marginal fringe free. The mouth (*m*) is situated on the border of the latter, and behind it is seen the muscular bulb of the

pharynx (*ph*) measuring 0·3 mm. in length. The somewhat weakly developed parapodia (*p*) are rather nearer the margin than the centre of the body; the oval suckers (*s*) lie halfway between the margin and the parapodia They measure 0·06 mm. in their longer diameter.

One specimen found lying loose in spirit with *Actinometra solaris*, *Actinometra bennetti*, and five species of *Antedon* from the Moluccas (K. zool. Genootschap, Amsterdam).

75. *Myzostoma furcatum*, n. sp. (Pl. II. figs. 5–7).

Recalling *Myzostoma lobatum*, Graff (Das Genus Myzostoma, Taf. ii.) in its four caudal appendages, into which the hind end of the body divides, as also in the unequal notching of the margin. The single specimen before me shelves off from the middle line towards the sides, and is bent upwards both anteriorly and posteriorly, so that no exact figure of the contour can be given. The lateral portions of the body are protruded anteriorly, so that in its extended state the middle of the anterior margin must appear to be turned in. The maximum length in the lateral portions, including the caudal appendages is nearly 8 mm. The inner pair of caudal appendages (ca_2) is a little longer than the outer pair (ca_1), and measures 1·5 mm. The latter have a conical form and an almost perfectly smooth surface without thinned lateral fringes. Nor are the marginal notches of the disc markedly thinner than the latter, and look more like warts compressed from above downwards.

Along the middle line of the back there extends a narrow, but sharply defined ridge (fig. 5, *aa*), and there are similar radial ridges, which extend on either side from beside the median pad on to the marginal notches. Each of the caudal appendages bears a similar ridge.

The colour is a dark warm sepia-brown, both above and below. The very strongly developed parapodia (fig. 6, *p*) lie in two almost parallel rows nearer the (depressed) middle line of the ventral surface than the margin, and almost halfway between them and the margin are the round and markedly projecting suckers (*s*). The pharynx (*ph*) is in this form stretched far forwards. On one side the blunt male genital papilla (♂) can be recognised.

Found lying loose in spirit with a black *Actinometra* (n. sp.), and several other Comatulæ from the Moluccas (K. zool. Genootschap, Amsterdam).

76. *Myzostoma membranaceum*, n. sp. (Pl. I. figs. 1–3).

Of this species I have two specimens before me, of which the larger is figured. It measures 7·5 mm. in length, and when the ventrally incurved sides were unfolded

must have had a maximum breadth of about 4 mm. The whole of the body-disc has an almost uniform thickness of about 0·25 to 0·33 mm., and is slightly translucent throughout, with the exception of the parapodial insertions. The margin is very finely notched; the colour uniformly greyish-yellow. The back bears a gently ridged longitudinal swelling (fig. 3), and at its sides five pairs of oval prominences, which represent the parapodial insertions on the ventral surface. No trace of suckers could be detected. The slightly developed parapodia (fig. 2, *p*) are disposed in two longitudinal rows, somewhat nearer the median line than the external margin, and the first pair is at an unusually great distance from the anterior end. The mouth (*ph.*) and cloacal papilla (*cl*) are also very small, and are situated at the extremities of a slight longitudinal ventral elevation representing the dorsal median ridge, and much nearer the margin of the body than the parapodia.

The smaller specimen is about 5 mm. in length, and is so completely bent in ventrally, that it has the form of a boat.

In the form of the body and in the absence of suckers this species seems closely related to *Myzostoma folium* (Report, pl. iii.).

Found on *Antedon marginata*, P. H. C., from Station 208 of the Challenger Expedition.

77. *Myzostoma beardi*, n. sp. (Pl. III. figs. 1–4).

I have named this species in honour of the successful investigator of the development of the Myzostomida, Dr. John Beard. In every respect this form very closely resembles *Myzostoma pentacrini* (Report, No. 61), with which I at first regarded it as identical. It causes on *Antedon flexilis*, P. H. C., the same deformity as the above species on the arms of *Pentacrinus alternicirrus*, P. H. C. The single specimen before me was obtained from the same *Antedon flexilis* (Station 192, Challenger Expedition, Arafura Sea) as the above described deformed pinnule with *Myzostoma willemoesii*.

The arm in question (Pl. III. figs. 1, 2) has been modified in the neighbourhood of a syzygy. The enlargement is most marked in the joint just below the syzygial one; and it extends upwards, not only on to the hypozygal (*a*), but also on to the epizygal joint, all three being somewhat expanded on the right side. The expanded portions are tubercled, and the most swollen joint, the one before the syzygy, has on the side a small funnel-shaped aperture (fig. 2), which leads into the cavity of the cyst. A second much larger opening is found, however, on the ambulacral side (fig. 3).

In this inconspicuous cyst, which would quite have escaped the notice of a less accurate observer than my friend Carpenter, lay the brown *Myzostoma* represented in fig. 4 from the ventral surface. There was certainly no second individual within the cyst.

The almost circular body has a diameter of 2·2 mm., and bears on its margin twenty cirri up to 0·17 mm. in length. So far there is no difference between this form and *Myzostoma pentacrini*, unless indeed in the fact that the body is somewhat less thick, and seems to be flattened out, so that only posteriorly and on the left side is there any curvature towards the dorsal surface. The mouth occupies, however, a subterminal position on the ventral surface, from which the short, broad, cloacal tube (fig. 4, *cl*) also arises. The parapodia (*p*) are furthermore considerably stronger than in the former, the male genital papilla (♂) is distinctly demonstrable on *both* sides, and the suckers are represented by shallow grooves with radial folds (*s*).

In addition to these points of difference, the intestine does not exhibit that extraordinarily abundant branching which is seen in *Myzostoma pentacrini*. The branches extend, however, close to the margin of the body, and in consequence of the marked expansion of the cæcal terminations appear to be closely packed.

78. *Myzostoma platypus*, n. sp. (Pl. III. figs. 7–12).

P. H. Carpenter sent me a *Myzostoma* cyst with the accompanying note:—"Among six individuals of *Actinometra nobilis* from Samboangan, I find one with some structures on the disk that I now recognise as *Myzostoma* cysts, though I did not know them in 1878. They seem to have no plating whatever, which is curious. I send you one with the *Myzostoma* inside which I cut from a corner where the disk was torn; and I shall have another part of the disk with a group of cysts drawn by my best artist.[1] They are always close to the ambulacral grooves and most frequently open into them, I suppose in order that the *Myzostoma* may get hold of some of the food particles which are travelling towards the mouth."

The cyst is figured in figs. 7 and 8, from the ambulacral surface, and from the side. The wall really exhibits no calcification and consists exclusively of a thin, delicate, readily pliable skin. It is transversely expanded below the ambulacral groove, and exhibits, close beside the latter, a slit-like aperture, through which the *Myzostoma* can be seen (*a*). The animal lies within the cyst transversely to the ambulacral groove, and the portion (*a*) which is seen in fig. 7 is the anterior end of the dorsal surface. The body is bent dorsally both in front and behind, so that the ventral surface has a markedly convex curvature. The latter lies close to the external convex wall of the cyst, and is attached to the same by means of the parapodia. The character of the ventral surface in this *Myzostoma* is very remarkable. In the first place, in the median line there is a conspicuous row of five raised, longitudinal ridges (fig. 9, 1 to 5). Their free surface is somewhat broadened and separated by sharp margins from the side, which slopes down to the surface of the body. These ridges, and also the parapodia

[1] See the forthcoming Report on the Crinoidea, Part II., pl. lxv. (Zool. Chall. Exp., part lx.).

(*p*), and the suckers (*s*), appear like raised plates fastened to the ventral surface. The contour of the parapodial plates is heart-shaped, and from their externally directed notch springs the cylindrical, terminal joint of the parapodium. Its origin is marked by a small swelling in the middle of the plate. The suckers are remarkably large. They also look like round, raised plates between the parapodia; but instead of the usual hole in the centre, there is only a slight, annular depression surrounding a small, central boss. The size and form of these suckers suggest that a careful investigation would yield some answer to the questions raised by Nansen in regard to the function and morphological import of these organs.

The mouth is situated below the anterior margin of the first ventral ridge, and in the specimen before me the anterior end of the pharynx (*ph*) is adorned with a circlet of delicate papillæ, 0·15 mm. in length. The cloaca seems to open close beside the posterior end.

Outside the third pair of parapodia lie the large male genital papillæ (♂). They are more strongly developed than in any other species, and exhibit a retort-like form. Their free tubular termination seems to be movable, since it is bent on either side in different directions, on the right side backwards, on the left forwards. The ventral surface unoccupied by the above organs appears to be finely canaliculated, which is probably an expression of the closely packed, radiating, intestinal branches. The dorsal surface examined under the lens does not exhibit any particular sculpturing.

The thickness of the body-disc is very considerable, and in the middle must measure almost 1 mm., gradually decreasing, however, towards the blunt margin, but without exhibiting any trace of a marginal fringe. On the other hand, the margin exhibits ten pairs of fine cirri, of which the first pair, distinctly represented in fig. 11 (*c*), attain a length of 0·58 mm.

The total length of the body in its elongated state must have been almost 6 mm.; the maximum breadth of the single specimen before me is 5 mm. The colour, above and below, is a uniform greyish-yellow.

THE CYSTS OF ANTEDON ROSACEA (Pl. IV.).

In 1885 P. H. Carpenter[1] directed attention to peculiar swellings which he very frequently observed on the pinnules, and less frequently on the arms, of the *Antedon rosacea* of European seas. From the results of the study of deformities produced by Myzostomida on Crinoids, Carpenter could not but regard it as probable that the malformation was in this case also referable to the same cause.

From the abundant material entrusted to me, I have in figs. 1 to 3 represented some of these deformities, magnified five times. The pinnule malformations are extraordinarily numerous, and occur on *Antedon rosacea* from the most diverse localities, as Carpenter has noted. Sometimes they are hardly noticeable thickenings of a single joint, or of two, less frequently of three adjacent joints (figs. 3, *a* and 2, *b*), sometimes larger spherical dilatations towards the adambulacral side (fig. 1, *a*). Somewhat rarely dilatations occur like that represented in fig 2, *a*, which is really only a pit surrounded by a thickened wall. On the other hand there are not unfrequently two or three such swellings on one and the same pinnule, and on a single arm of an *Antedon rosacea* from Milford I counted seven of the malformations, and in all fourteen characteristic swellings on one individual.

Less numerous are the arm-swellings, such as that represented in fig 2, *c*. On that specimen (collected by the "Vettor Pisani" near Gibraltar), three distinct deformities occur in close approximation. The very slight arm-swelling extends over two joints, and is tolerably uniform on either side. I have observed, however, one-sided conical swellings of the arm-joints, sometimes combined with an enlargement of the basal joint of the attached pinnules.

I have opened fourteen of these malformations of *Antedon rosacea* under a lens, and, after decalcifying them, have cut longitudinal sections, but in no case have I found a *Myzostoma* or any other encysted organism. On the contrary, both in the various pinnule deformities and in the arm-swellings, I found a roundish brown foreign body, which was apparently the cause of the deformity, though it was not possible for me to determine anything definitely as to its nature or origin.

In fig. 4 one of these bodies is represented, which I removed from the pinnule swelling of an *Antedon* from Cumbrae. The diameter of the sphere measured 0·3 mm., and the substance was distinctly divisible into a strongly refracting cortical layer and an opaque granular internal mass. The former was radially divided into cell-like portions, and had quite the appearance of cylinder epithelium both in optical section (*a*) and on surface view (*c*). There was not however any sharp boundary between the outer layer and the central mass. The whole had thus the appearance of a superficially segmented ovum.

[1] *Nature*, 1885, vol. xxxii. p. 391 ; vol. xxxiii. p. 8.

These bodies sometimes lie in the centre of the swollen joint in the calcareous substance (*cf.* the longitudinal section, fig. 6), or near the integument (fig. 5), or even embedded in the latter as it was the case in the walled pit of fig. 2, *a*. In sections, one always finds that this egg-like body is surrounded by a non-calcified tissue (*m*), uniformly stained by carmine. When the body lies close below the integument (fig. 5) the tissue is connected with the latter.

The sections shed no light upon the nature of the contained body. In fig. 5, which represents a body with a diameter of 0·26 mm., the more darkly stained cortical substance appears in part roughly divided, and in the central mass also there are fine lines which suggest a similar division; when the contents are compressed they fall into clumps like yolk segments.

In fig. 6 the smaller swelling (*a*) contains a single body with a diameter of 0·058 mm., in which no structure could be detected, and the distinction between cortical and central mass was less obvious. On the other hand, in the three bodies (*b*, *c d*), which are contained in the larger swelling of the same pinnule, and which measure from 0·1 to 0·12 mm. in diameter, the structure described in fig. 4 is already indicated. That these structures are not ova seems to me to follow from the fact that none of the stained preparations exhibited any trace of nuclei.

Furthur investigation is therefore necessary in order to elucidate the nature of the cyst contents.

PLATE I.

PLATE I.

The following letters have the same signification throughout.

cl. Cloacal papilla or opening.
i. Intestine.
m. Mouth.
p. Parapodium.
ph. Pharynx.
s. Sucker.
♂. Male genital papilla or opening.

Figs. 1–3. *Myzostoma membranaceum*, n. sp.

Figs. 1, 2. The animal, from the ventral side ; magnified $5\frac{1}{2}$ diameters.

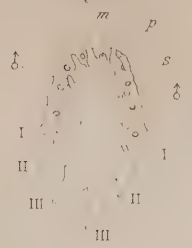
Fig. 3. The same, from the dorsal side.

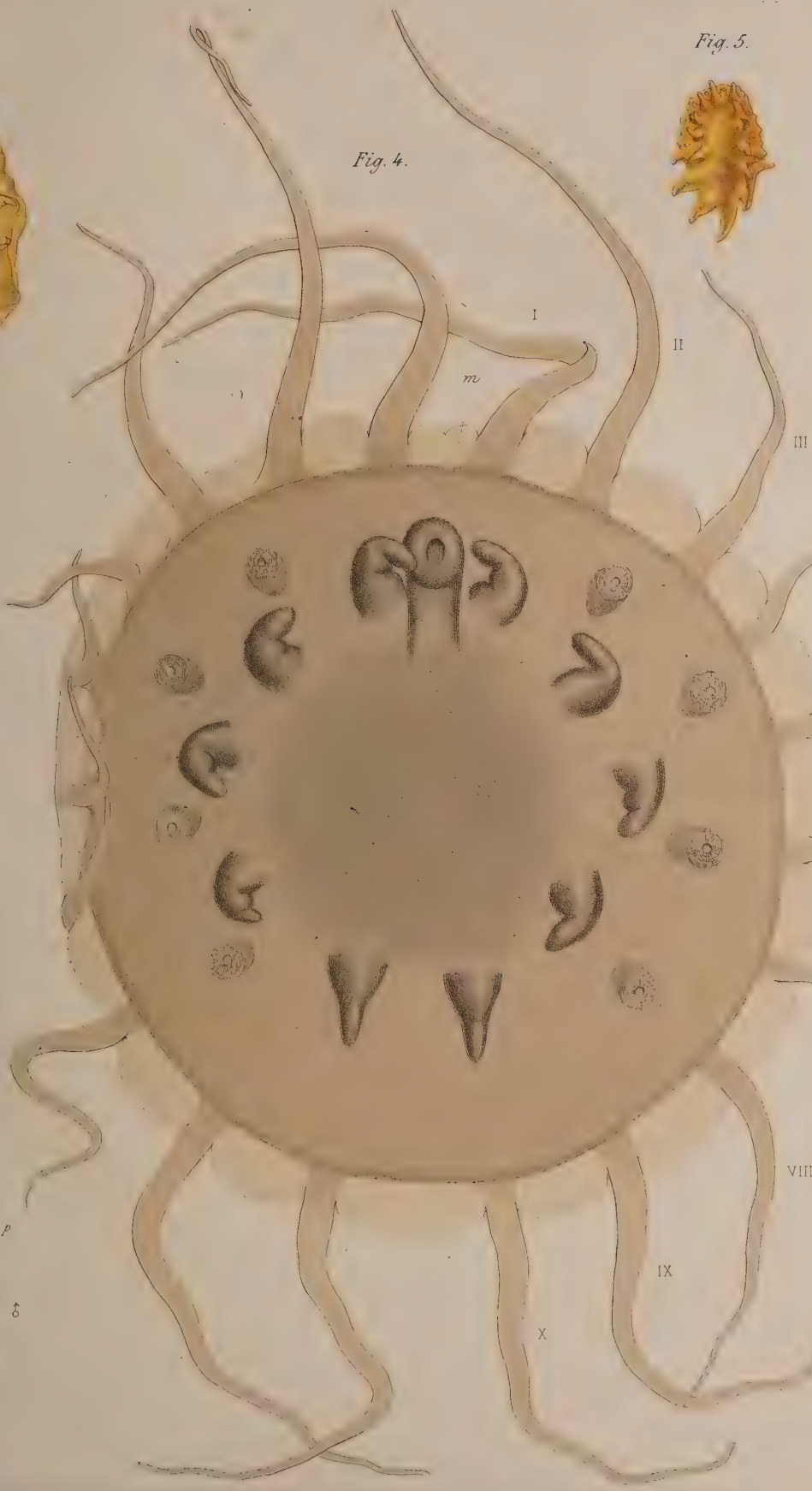
Fig. 4. *Myzostoma longicirrum*, n. sp.

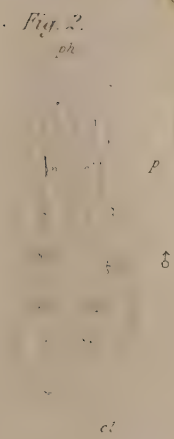
Fig. 4. Seen from the ventral side; magnified 108 diameters; Nos. I–X, the number of the cirri.

Figs. 5, 6. *Myzostoma fissum*, Graff.

Figs. 5, 6. Seen from the ventral side; magnified $5\frac{1}{2}$ diameters; Nos. I–III, the three pairs of caudal appendages.







1-3. MYZOSTOMA MEMBRANACEUM, 4. M. LONGICIRRUM, 5-6. M. FISSUM.

F Huth, Lith^r Edin^r

PLATE II.

PLATE II.

The following letters have the same signification throughout.

cl. Cloacal papilla or opening.
i. Intestine.
m. Mouth.
p. Parapodium.
ph. Pharynx.
s. Sucker.
♂. Male genital papilla or opening.

Fig. 1. *Myzostoma ambiguum*, n. sp.

Fig. 1. The animal, seen from the ventral side; magnified 75 diameters; Nos. I–X, the numbers of the cirri.

Figs. 2, 3. *Myzostoma nanseni*, n. sp.

Figs. 2, 3. Seen from the ventral side; magnified $5\frac{1}{2}$ diameters.

Fig. 4. *Myzostoma gigas*, Lütken.

Fig. 4. The left margin with the supernumerary cirrus (*c*) between the seventh and eighth normal cirrus.

Figs. 5–7. *Myzostoma furcatum*, n. sp.

Fig. 5. The animal, seen from the right dorsal side; magnified $5\frac{1}{2}$ diameters; with the median dorsal elevation (*a–a*).

Figs. 6, 7. The same, from the ventral side. ca_1, the outer, ca_2, the inner caudal appendage.

Fig. 2.

Fig. 1.

Fig. 3.

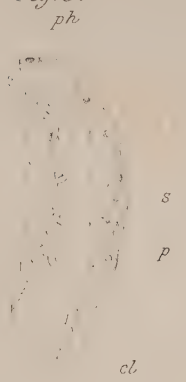


Fig. 4.

Fig. 6.

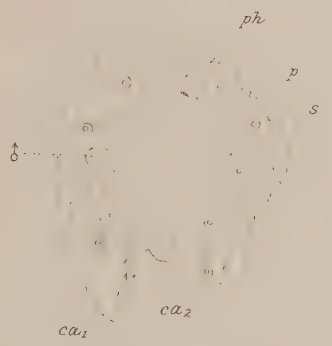


Fig. 7.

Fig. 5.

L. v Graff fec. F Huth, Lith^r Edin^r

1. MYZOSTOMA AMBIGUUM, 2-3. M. NANSENI, 4. M. GIGAS, 5-7. M. FURCATUM.

PLATE III.

PLATE III.

The following letters have the same signification throughout.

cl. Cloacal papilla.
p. Parapodium.
ph. Pharynx.
s. Sucker.
♂. Male genital papilla.

Figs. 1–4. *Myzostoma beardi*, n. sp.

Figs. 1–3. Three aspects of the arm swelling. *a*, the hypozygal of the syzygy.

Fig. 4 The *Myzostoma*, seen from the ventral side; magnified 38 diameters.

Figs. 5, 6. *Myzostoma willemoesii*, Graff.

Fig. 5. The deformed pinnule, with the enlarged ambulacral furrow (*) and its free (not deformed) end (*a*); magnified $5\frac{1}{2}$ diameters.

Fig. 6. The left margin of the body with (III–VII) cirri.

Figs. 7–12. *Myzostoma platypus*, n. sp.

Figs. 7, 8. Two views of the cyst. *a*, the *Myzostoma* visible at the opening of the cyst; magnified $5\frac{1}{2}$ diameters.

Figs. 9, 10. The *Myzostoma*, seen from the ventral side, with its median elevations (1–5); magnified $5\frac{1}{2}$ diameters.

Figs. 11, 12. The same, seen from the anterior end, with the first pair of cirri (*c*); magnified $5\frac{1}{2}$ diameters.

Fig. 1.

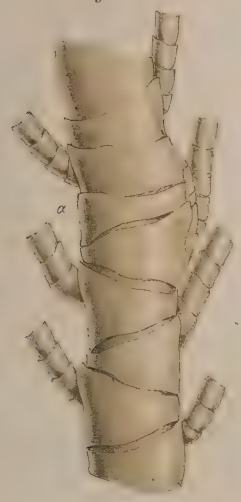


Fig. 2.

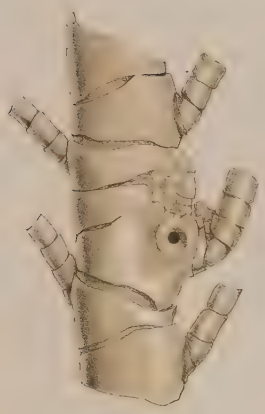


Fig. 3.

Fig. 4.

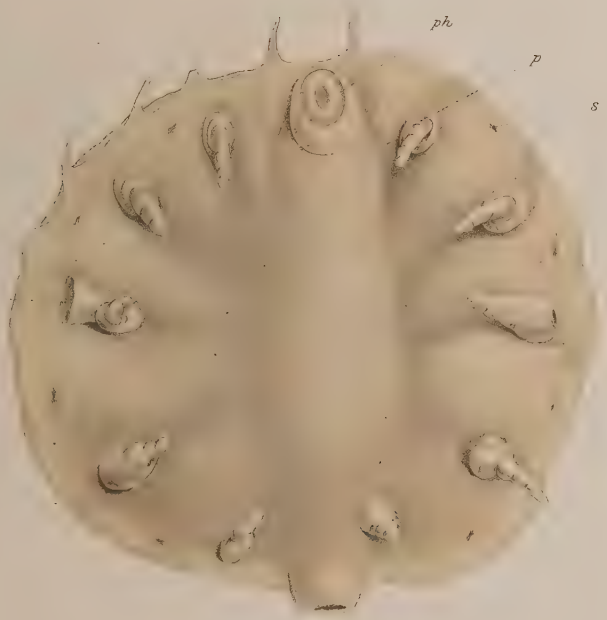


Fig. 5.

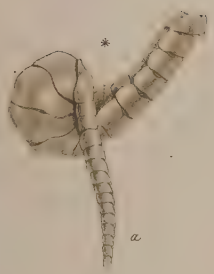


Fig. 6.

Fig. 9.

Fig. 11.

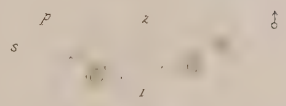


Fig. 7.

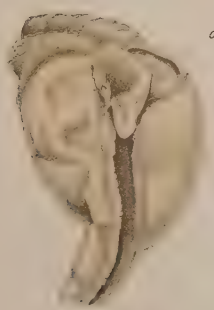


Fig. 8.

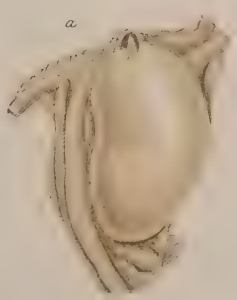


Fig. 10.

Fig. 12.

PLATE IV.

PLATE IV.

All the Figures refer to *Antedon rosacea*.

Figs. 1 and 3. The pinnule cysts (*a*) from an *Antedon*, dredged by the Liverpool Marine Biological Committee, off Keumaes Bay, north coast of Anglesea.

Fig. 2. Three deformities from an *Antedon*, dredged by the steamer "Vettor Pisani" at Gibraltar. *a*, a groove-like deformity; *b*, a pinnule-cyst; *c*, an arm-swelling.

Fig. 4. The egg-like content of a pinnule-cyst from an *Antedon*, from Cumbrae. The right side (*c*) is drawn in surface-view; the left side in optical section, with the cortical layer (*a*) and the internal mass (*b*).

Fig. 5. Longitudinal section through a pinnule deformity, showing the content (*a*), enclosed in an uncalcified tissue (*m*). From the same locality as fig. 1.

Fig. 6. Longitudinal section through a doubly deformed pinnule of an *Antedon*, from Milford Haven, with four contents (*a–d*).

(Figs. 1–3 are enlarged 5 times, figs. 4–6, 75 times.)

Fig. 1.

Fig. 2.

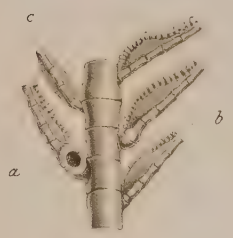


Fig. 3.

Fig. 4.

Fig. 5.

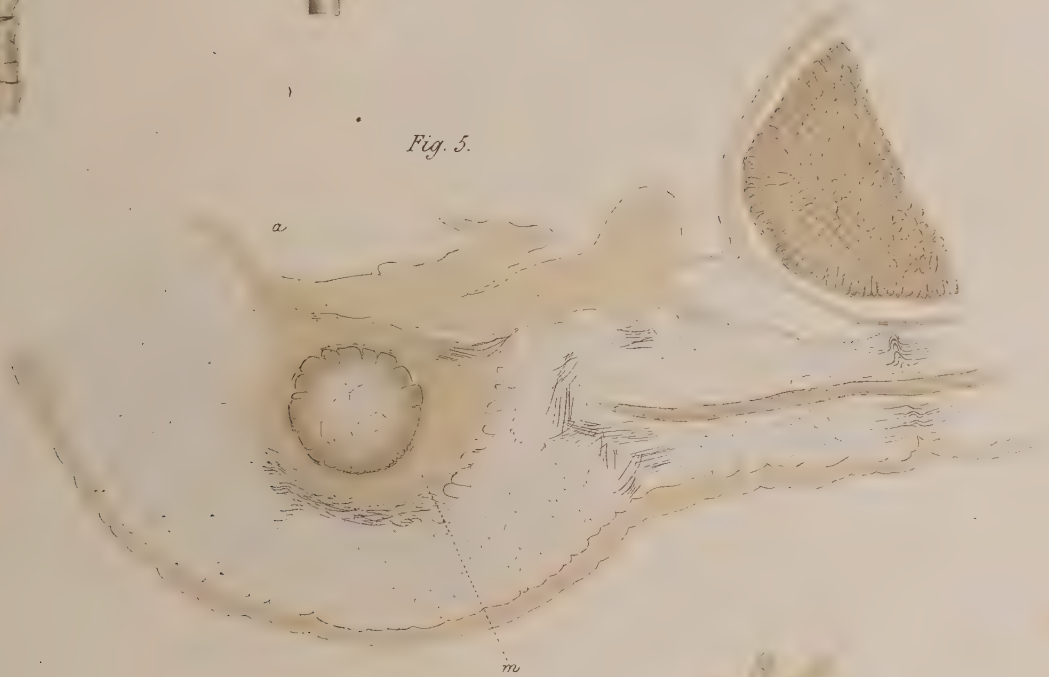
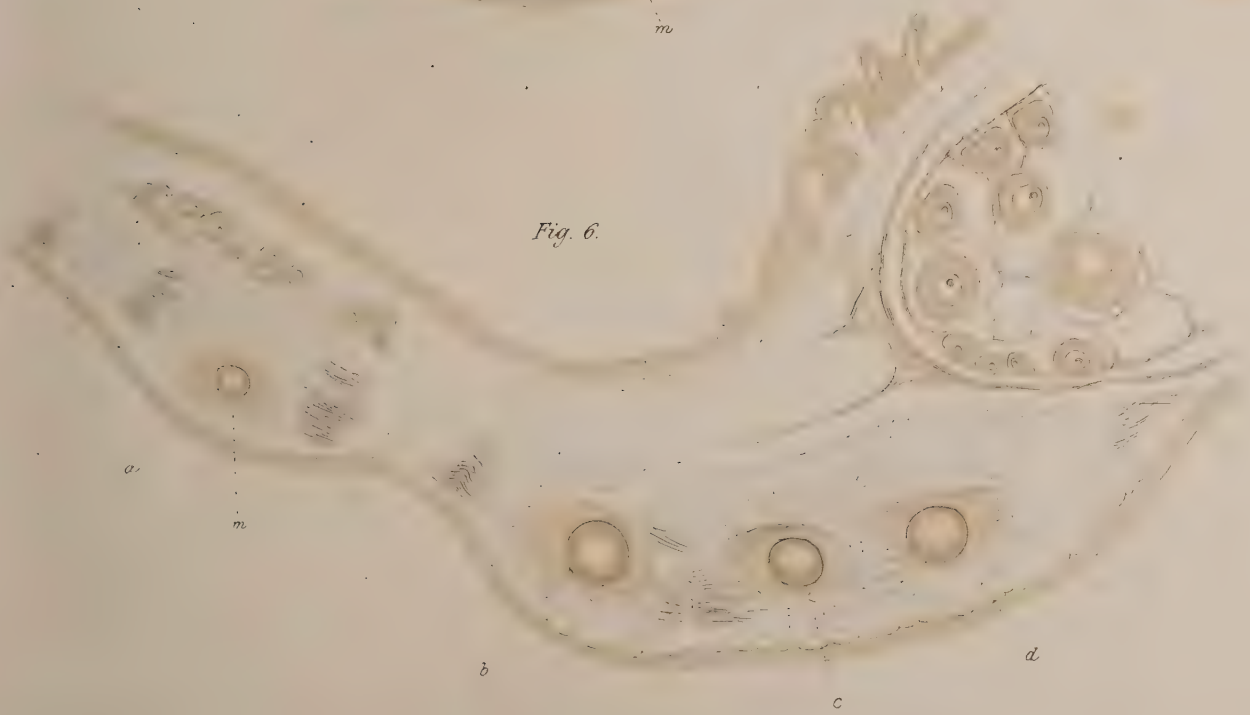


Fig. 6.



F. Huth, Lith^r Edin^r

1-6 CYSTS FROM ANTEDON ROSACEA.

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INVESTIGATIONS

REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND THE LATE

CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF

THE LATE

Sir C. WYVILLE THOMSON, Knt., F.R.S., &c.

REGIUS PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF EDINBURGH

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ZOOLOGY—VOL. XX.

PART LXII.—REPORT ON CEPHALODISCUS DODECALOPHUS

BY WILLIAM C. M'INTOSH, M.D., LL.D., F.R.S., &c.

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PACIFIC OCEANIC FISH

PRINTED BY NEILL AND COMPANY, EDINBURGH,
FOR HER MAJESTY'S STATIONERY OFFICE.

EDITORIAL NOTE.

This Report consists of a description by Professor William C. M'Intosh, F.R.S., of Cephalodiscus dodecalophus, one of the most curious and interesting organisms dredged by the Expedition, with an Appendix on its affinities by Sidney F. Harmer, B.A., B.Sc., Fellow of King's College, Cambridge. It contains forty-eight pages, and is accompanied by seven plates and woodcuts.

The Manuscript was received in instalments between 25th April 1887 and 19th May 1887.

John Murray.

Challenger Office, 32 Queen Street,
Edinburgh, 22*nd July* 1887.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on CEPHALODISCUS DODECALOPHUS, M'Intosh, a new type of the POLYZOA, procured on the Voyage of H.M.S. Challenger during the Years 1873–76. By WILLIAM C. M'INTOSH, M.D., LL.D., F.R.S., &c., Professor of Natural History in the University of St. Andrews.

Class POLYZOA, J. V. Thompson.

Section ASPIDOPHORA, G. J. Allman.

Genus *Cephalodiscus*, M'Intosh.

Cephalodiscus dodecalophus, M'Intosh.

Cephalodiscus dodecalophus, M'Intosh, Ann. and Mag. Nat. Hist., ser. 5, vol. x., 1882, p. 337, *et seq.*

Among the collections made by the Challenger Expedition in the Strait of Magellan, there was a structure which, from its external appearance, was in the first instance placed among the Compound Ascidians. When it was found not to belong to this group Mr. John Murray forwarded the specimen to various authorities for examination, and subsequently my attention was drawn to the anomalous organism in the hope that it might be found to have affinities with the Annelida. An examination of this remarkable type proved that amongst its other relations it was an ally of *Rhabdopleura*, a new type of the Polyzoa which had been ably described and figured by Professor Allman in 1869[1]

[1] *Quart. Journ. Micr. Sci.*, vol. ix., N.S., 1869, pp. 57–63, pl. viii.

from specimens procured at a depth of 90 fathoms in the Zetlandic Seas by Drs. Gwyn Jeffreys and Merle Norman; and which had received further elucidation at the skilled hands of Professor G. O. Sars,[1] as an inhabitant of the still waters in the deeps off the Lofoten Islands. Though it thus fell within the department of Professor Allman, or that of the late lamented Professor Busk (each of whom had arrived at a similar conclusion in regard to its systematic position), yet both most disinterestedly desired that its description should remain in my hands. A preliminary account accordingly appeared in the Annals and Magazine of Natural History for November 1882,[2] having been previously communicated to the Southampton meeting of the British Association.

The specimens of this remarkable form were trawled at Station 311 (in the Strait of Magellan), January 11, 1876; lat. 52° 45′ 30″ S., long. 73° 46′ 0″ W.; at a depth of 245 fathoms; bottom, blue mud; temperature at the bottom 46°·0, surface 50°·0; specific gravity at the bottom 1·02454, surface 1·01904. The bag of the trawl in this region was filled, Mr. Murray tells me, with a vast mass of *Hemiasters*, numerous examples of a *Venus*, and multitudes of Compound Ascidians, four species of which have been described by Professor Herdman, who also noticed the distinction between *Cephalodiscus* and the Ascidians. Further, in connection with the habitat of the new form, it is interesting that several peculiar molluscoid rarities had previously been found in the Strait of Magellan by Professor R. O. Cunningham, naturalist on board H.M.S. "Nassau," such as his *Goodsiria coccinea*, a long, lobed, rooted fibro-gelatinous mass of a vivid scarlet colour, with the minute flask-shaped animals in circumferential cells, and the equally curious *Pyura molinæ*, of Blainville. Thus if the Strait be not the head-quarters of peculiar Molluscoida, it is certainly one of the centres round which many are grouped, including the present new type—perhaps the most remarkable of them all.

Amongst the branches of the cœnœcium of *Cephalodiscus* were a few minute Arachnida, sessile-eyed Crustaceans, fragments of Annelids and sponges, besides many Foraminifera of the Rotulate type, which were chiefly studded on the spines (or filaments) and other parts.

[1] On some Remarkable Forms of Animal Life, &c., vol. i., 1872, pp. 1–18, Tab. i., ii.
[2] Ser. 5, vol. x. p. 337.

DESCRIPTION.

The description of this peculiar type may be taken under the following heads :—

I. The House or Cœnœcium ;
II. The Polypides, including—
- *a.* Buccal disk.
- *b.* Branchial plumes.
- *c.* Digestive system.
  - Mouth.
  - Pharynx.
  - Œsophagus.
  - Stomach.
  - Pyloric chamber.
  - Intestine.
  - Food.
- *d.* Body-wall and body-cavities.
- *e.* Muscular system and pedicle.
- *f.* Nervous system.
- *g.* Reproductive organs.
- *h.* Budding.

III. General Remarks and Homologies.

I. Cœnœcium.

At first sight the flexible cœnœcium might be mistaken for a sea-weed, since it is composed of a much branched fucoid tissue, tinged of a pale brownish hue, and semi-translucent. Moreover the whole surface of the thickish stems is hispid with long tapering spinous processes or fimbriæ of the same tough secretion, and perforated here and there by somewhat large apertures with smoothly rounded edges. A more minute inspection reveals various opaque bodies in groups in the interior of the branches; and the appearance of these suggested the relationship of the structure to the Polyzoa or Ascidians. When first seen in the Strait of Magellan it was supposed, Mr. Murray observes, to be a Compound Ascidian. After having subjected it to more careful examination on the completion of the voyage, the late lamented Professor Busk, however, pointed out its distinction from the ordinary Polyzoa; while Professor Herdman, as already mentioned, was satisfied it did not fall under the Ascidians.

The house or cœnœcium of *Cephalodiscus dodecalophus*[1] (Pl. I. fig. 1) consists of

[1] κεφαλή, head; δίσκος, disk; δώδεκα, twelve; λόφος, plume.

thickish, irregularly rounded or flattened stems of the consistency of soft sea-weed, and having a slight lustre like the semitransparent tubes of many Annelids. The stems have a diameter varying from four or five millimetres to double or treble that breadth in the flattened expansions; but the general size of many of the branches is nearly uniform. They cover a considerable area with their network, the extreme length in one example being about 9 inches, and the breadth 5 or 6 inches. The main trunks appear to have sprung from submarine objects, such as stones or sponges, but instead of standing erect as in a soft Gorgonian, to which the inosculations of the branches give it some resemblance, they seem to have been more or less horizontal, since pillars of the

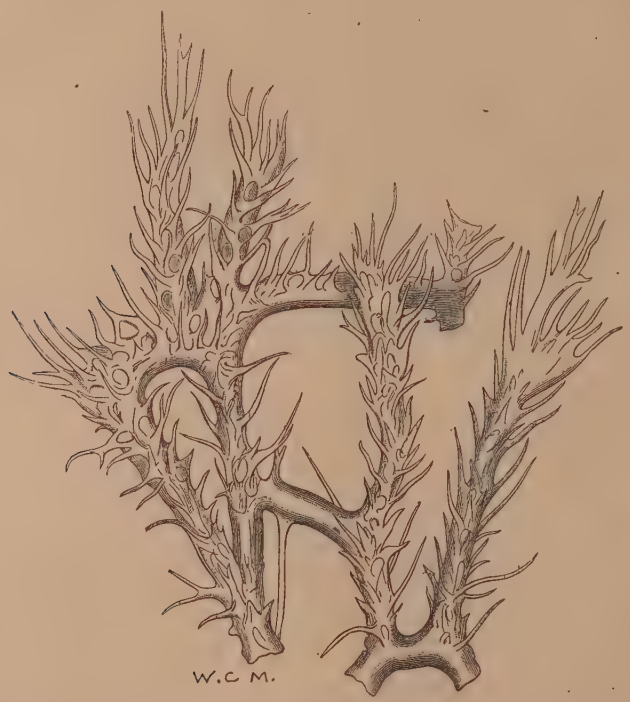

Fig. 1.—Fragment of Polyzoarium of *Cephalodiscus dodecalophus*, M'Intosh.

cœnœcium occasionally pass, like aërial roots, from the underside to the plane of attachment. Various foreign bodies, such as tubes of Serpulæ and portions of sponge, are, moreover, occasionally enveloped by the cœnœcium, the originally soft secretion having insinuated itself into all the irregularities of their surfaces, and extended around and beyond them. The surface of the branches is everywhere studded with elevations and ridges, which terminate in long spines of the same tissue—simple, bifid, trifid or multifid—and here and there bending downward to join the main stem, so as to form loops and arches, or inosculating with adjacent spines or fimbriæ (woodcut, fig. 1). Some of the

spinous processes are very large, and project far beyond the others, while occasionally they occur in groups. They generally taper a little towards the tip, which is often attenuate, and of a deeper brownish hue than the rest of the cœnœcium (Pl. VII. fig. 1). The free tips of the branches frequently show a somewhat palmate arrangement, with longer spines variously divided. The irregularity in regard to the distribution of the spines recalls the processes on the peculiar sponge *Chondrocladia*, though this feature is much more marked than in the latter. All the spines are hollow, and in connection with the canals and cavities of the cœnœcium.

The surface of the cœnœcium, moreover, is dotted, especially at the bases of the spines, with large rounded apertures, which lead into the interior of the stem, the latter being honeycombed from end to end by an irregular system of wide canals and somewhat rounded cavities, intersected by bridles and arches, which thus provide for the constant ingress and egress of sea-water throughout the entire system. The inner wall of these canals and chambers is as smooth and glistening as the outer surface of the cœnœcium, the secretion being perfectly homogeneous. It cuts with great readiness, and as cleanly as a soft *Fucus;* while it is much less tough than the glistening tubes of the Annelids. Microscopically it is composed of numerous layers of a translucent and very fine membranous secretion, so that in the preparations there are endless lines and folds, while the sheen or lustre is doubtless due to the same arrangement.[1] The whole disposition of the tissue clearly indicates that it is the work of the polypides, just as much as the tube of an Annelid or *Phoronis*, the more regular and less bulky tube of *Rhabdopleura*, and in some respects the shell of a Mollusk. Like the Annelidan tubes it most approaches, it is little affected at first either by nitric acid or caustic potash, though the former after a time somewhat softens and bleaches it.

This secretion of *Cephalodiscus* is paralleled by the curious investment or "house" of *Appendicularia*, which by some has been held to be the homologue of the Ascidian test, and which fills the tow-net with a semi-solid mass when the animals are abundant. It differs considerably from the branched system of annulated tubes formed by *Rhabdopleura*, each of these corresponding to a single polypide, while the rings of which it is composed are successively produced at the termination of the tube by the secreting powers of the great buccal shield or præ-oral disk. Professor Lankester, moreover, has very clearly explained[2] that the differences of the rings in the attached or recumbent part of the tube and those of the erect portion—differences first pointed out and figured by Professor Allman[3]—are due to the changes in the buccal disk which secretes them, this disk being characteristically bifid in the young specimens which form the recumbent portion of the tube. This symmetry and regularity are absent in the house of *Cephalo-*

[1] All these features are well seen in a series of sections mounted by the dextrous hands of the late Professor Busk.
[2] *Quart. Journ. Micr. Sci.*, vol. xxiv., N. S., p. 625.
[3] *Journ. Roy. Micr. Soc.*, vol. ix. pp. 61–62, pl. viii. figs. 4, 6, &c., 1869.

discus, apparently because the polypides are not restricted and regulated in their labours by the contractile stalk, but are free to wander throughout the cœnœcium, and to add layer upon layer to strengthen their protective investment. The buccal shield is in all probability the chief secreting organ, the great sheets of membrane, consisting of the secretion hardened in sea-water, being formed by its agency, but the shape of the spinous processes or fimbriæ suggest some other assistance, such as might be obtained from the enlarged and glandular tips of the plumose arms.

While there can be little question that the protective house of *Cephalodiscus* differs materially from the thickened cuticle of the posterior region of the polypides in the ordinary Polyzoa, and which collectively is termed zoœcium, yet it seems unnecessary to complicate the subject by the introduction of new nomenclature.[1] The term cœnœcium, instituted by Professor Allman, which was used in the preliminary description, points to an obvious character, and gives that amount of significance which it is always well to preserve if possible in scientific terms. The term tubarium, proposed by my friend Professor Lankester, is very appropriate in the case of *Rhabdopleura*, but does not apply to the condition in *Cephalodiscus*, in which the common abode of the polypides is more aptly indicated by the already existent term cœnœcium.

It is not a matter for surprise that creatures so minute should secrete so conspicuous a home for themselves, or that it should assume the algoid or zoophytic outline, especially when the productions of sponges and other forms are remembered, or when we reflect that even a transparent structureless fluid inside a smooth capsule (as in the Nemertean stylet-pouch) can produce, in countless examples of each species, precisely the same form of solid crystalline stylet. The enlistment of numbers in the present case supplies any deficiency likely to arise from minute size. The secretions, indeed, both of this form and *Rhabdopleura*, are most interesting, and indicate a degree of skill and persistence of pattern quite as marked as in much more elevated types. The condition in *Cephalodiscus* is perhaps the more striking of the two, on account of the perfect freedom of the polypides, the spinous processes or fimbriæ of the surface, and the numerous anastomoses of the cœnœcium. The peculiar shape of the latter, moreover, has probably been found to be that best adapted for the preservation of the animals, by its resemblance to seaweeds or allied structures in the neighbourhood, on the one hand, and on the other, by its affording complete aeration, abundant supply of food, and security to the little architects and their delicate plumes.

II. Polypides.

The rounded cavities and canals of the semitransparent cœnœcium contain numerous opaque masses (the polypides) and large ova slightly attached by their peduncles. The former often occur in groups, each individual, however, except in the case of buds,

[1] *E.*., Edicularium.

being perfectly free, and at liberty to wander anywhere along the chambers or externally through the apertures. In some cases they are packed closely together in the cavity, probably from external causes acting after immersion in spirit; for thin partitions, bridles, and pillars of the semitransparent cœnœcium often separate the individuals. The cavities are generally clean, though occasionally a little mud containing sponge and other spicules, including peculiar reticulated fragments apparently of Radiolarians, occurs. This would seem to show that currents of sea-water sweep through these chambers very freely, probably assisted by the active movements of the cilia covering the tentacular plumes. Moreover, in dissecting out the latter, an operation performed with ease, owing to the friability of the cœnœcium, at first sight it may almost be supposed than an ovigerous envelope containing embryos is before us, so remarkable is the profusion of eggs and animals, and apparently so active is the reproductive function. The aspect of the adults and their terminal buds, the proportionally large size of the ova, and other features, however, negative such a supposition.

Fig. 2.—Ventral view of *Cephalodiscus dodecalophus*, M'Intosh.

Each adult polypide (and they are somewhat uniform in size) measures, from the extremity of the cephalic plumes to the tip of the pedicle, about two millimetres (woodcut, fig. 2); and of this length the body-proper—that is from the buccal disk to the posterior bulbous region above the pedicle,—is rather more than one millimetre. The body in most is bean- or kidney-shaped (Pl. II. fig. 1), generally more rounded and bulbous posteriorly, since there is a tendency to a forward curve behind the pedicle. The dorsal surface is smooth and convex, a distinct constriction, however, being usually evident just behind the anterior region bearing the brownish-red pigment-spots. The latter region is generally bulbous and prominent, and in many a slightly elevated median ridge leading to the anus is present. So far as the spirit-preparations go, therefore, the external differentiation of the anterior region, called "thoracic" by Lankester in *Rhabdopleura*, is indistinct in *Cephalodiscus*, but internally the collar body-cavities are diagnostic. As the pedicle is often curved forward or projected outward at a small angle to the body, the ventral surface is thus rendered comparatively short (Pl. III. fig. 2); indeed, in those which are much bent, the base of the pedicle touches the buccal disk. This contour of the body is interesting in relation to the oblique direction of the cup-like body of *Loxosoma*. When

the pedicle is extended (Pl. III. fig. 1) the ventral surface is nearly straight and continuous with the pedicle, which leaves the body posteriorly at the ventral edge, while the kidney-shaped mass of the body projects dorsally. The pedicle in contraction is shorter than the body, is nearly cylindrical, and terminates in either a rounded or somewhat flattened end; but in extreme elongation (Pl. III. fig. 1) its appearance is much more attenuate. It is marked ventrally by various longitudinal striæ from the muscular bands.

The anterior region of the body curves somewhat suddenly downwards and backwards, and forms a flattened surface on which the great buccal disk or præ-oral lobe rests.

Buccal Disk.

The great buccal disk (Pl. II.; Pl. VI., fig. 2, *bs*) forms a thin plate with two slight and generally bilaterally arranged elevations in the centre anteriorly, and is divided into two regions by a notch at each side, the anterior moiety being the larger and thicker. The surface of the latter is marked by an arch of brownish pigment-grains, which are densest in the centre of the curve, and shade off gradually on each side; while a very conspicuous and well-defined deep brownish-red band commences in the posterior division at the notch, and runs with a backward curve to the opposite side. Between this and the posterior margin a brownish pigment-belt—less developed than in front—occurs. The two bands just mentioned form, when completed, a somewhat flattened ring. In many specimens, however, the brownish pigment has been entirely removed by the spirit, leaving only the well-defined reddish band posteriorly.

In intimate structure (Pl. VI. figs. 2, 3, *bs*)[1] the disk is found to consist of a ventral plate, the superficial characters of which have been described, and a pedicle. In section the former presents the features of a great hypodermic shield somewhat similar in structure to the Nemertean or Annelidan skin, and the surface of which in life is probably clothed with cilia, as indeed Professor G. O. Sars found in *Rhabdopleura*, though no distinct cuticular layer is visible in the preparations. This hypodermic tissue is marked in section by vertical striæ, which in the thick anterior central region assume a somewhat radiate aspect. The free parts of the shield present dorsally a firm basement-tissue under the cuticle, while ventrally, that is, on the secreting surface, the granular glandular tissue terminates in a translucent smooth edge. As the pedicle is approached, a narrow reticulated region appears within the basement-tissue strengthening the dorsal region of the disk, and the inner as well as the outer wall of this region assumes a firm structure—so as to resemble the basement-tissue. In the centre of the pedicle this region is traversed by a radiate series of muscular fibres, which spring from the firm tissue, constituting a kind of skeleton strengthening the basal part with which the plumes are

[1] I am much indebted to my assistant, Mr. John Wilson, B.Sc., for making a series of finely stained sections of *Cephalodiscus*. These have enabled me to determine features not fully seen in unstained sections made in cork by the hand.

connected. From this insertion they radiate into the thick central mass of the shield, and some appear to reach the pale ventral region of the hypoderm. Somewhat behind the former region the fibres also arise from the basement-tissue lining the hypodermic investment of the pedicle. This fan-like arrangement of the muscular fibres must confer great mobility on the disk, so that its broad scale-like surface can be applied either as a sucker or in an undulatory or partial manner, indeed enabling it to act as a useful locomotive organ. In this connection also it is probable that the basement-tissue may be highly elastic, especially in the absence of any signs of horizontal or transverse muscular fibres, and in connection with the entrance or exit of fluid by the proboscis pores. The glandular nature of the disk, again, shows that it is a structure with secerning powers of great activity, and in close relation with the remarkable cœnœcium. Superiorly the pedicle of the buccal disk runs into the region at the base of the arms, and in sections a fine layer of longitudinal and oblique muscular fibres occurs on the inner surface of the dorsal wall of the pedicle, though such have not yet been seen anywhere on the inner surface of the shield.

In the centre of the buccal shield is a large mesoblastic cavity through which the radiate muscular fibres before mentioned pass, and which communicates with the exterior by two well-marked pores situated dorsally on each side of the middle line at the great central nervous system. In oblique sections (*e.g.* Pl. VI. fig. 3, *bp*) these pores lie close together in their progress inwards. What relation the ciliated "sense" organ of *Rhabdopleura*, as described by Sars, and also figured by Lankester, may have to the proboscis-pores of *Cephalodiscus* is a feature of moment for future consideration. In *Cephalodiscus* these pores seem to be formed by invaginations of the hypoderm of the region, but their function is as uncertain as the single pore perforating the nervous system in the proboscis of *Balanoglossus*. The proboscis in the latter is much more muscular and has an evident proboscis-gland.

While therefore the buccal disk of *Cephalodiscus* is in all probability the main organ of locomotion, just as in *Rhabdopleura*, which was seen by Professor G. O. Sars drawing itself up to the aperture of its tube, it differs from the shield of the latter by its much greater size.

In the form just mentioned the organ somewhat resembles the truncated and thickened opercular process of certain Annelids, while in *Cephalodiscus* it overlaps the neighbouring parts to a great extent. The intimate structure of the shield in *Rhabdopleura* has only been alluded to by Sars, and he does not appear to have clearly made it out. He says—"On examining more closely this buccal shield we observe in the middle of it an opaque part which seems to contain an interior glandular organ. Continuing the investigation and slightly pressing the animal, we notice, however, that this opaque appearance is not produced by any such internal organ, but by a peculiar and seemingly muscular structure of the shield itself. It exhibits, seen from below, in

the middle numerous small bubbles situated rather far from each other, or somewhat irregularly formed small cells, which, however, when more closely examined (and this is particularly evident in those which lie nearer to the periphery of the disc), show themselves to be external rounded extremities of small inwardly prolonged cylinders, which together appear to form a thick fascicle of incompletely differenced muscular fibres penetrating into the stalk of the buccal shield." He thus does not refer to the structure of the hypoderm of the disk, and yet this is one of its most important features, especially in connection with its functions. In all probability, however, it closely agrees with the hypoderm in the disk of *Cephalodiscus*, and the muscular fibres described by Sars no doubt arise from the basement-tissue connected with the lophophoral arms, and radiate in a fan-like manner into the hypoderm of the præ-oral shield. Further examination of *Rhabdopleura* would also appear to be necessary in regard to the presence or absence of a præ-oral cavity and proboscidian pores as seen in *Cephalodiscus* and *Balanoglossus*.

The buccal disk is apparently the homologue of the epistome in the ordinary Polyzoa. It is also interesting to find paired spaces in the epistome of *Loxosoma*.[1]

The hypoderm of the buccal disk folds evenly over anteriorly to pass backwards and upwards to the pedicle, and as the latter is connected with the basal framework of the arms, this region forms the common ground for the origin of the twelve plumes.[2] On removing the disk, some of the plumes often remain attached to the pedicle, while others in the lateral regions are fixed to the basal tissue in front of the broad apron-like post-oral lamella on each side.

In transverse section the centre of the disk, even in early buds, presents a large median chamber, traversed by the radiate fibres of its muscular system, and communicating with the exterior through the pair of pores occurring in the region of the nervous system. It would thus seem that sea-water could be admitted into the interior, though, perhaps, this is by no means indispensable for the performance of its functions. Mr. S. F. Harmer has drawn my attention to the great similarity between the proboscis of *Balanoglossus* and this organ (buccal shield) in *Cephalodiscus*, though, it is true, only a single proboscis-pore leading through the nerve-ring of the stalk exists in the former, which likewise has a proboscis-gland and the so-called "heart." The functions of the organs differ very considerably, but there can be little doubt as to the nature of the interesting homologies between the two forms.

Branchial Plumes.

From the dorsal edge of the basal region just described, twelve plumes arise almost in linear series, six on the one side of the median line and six on the other. A thickened hypodermic area, with a median fissure, is visible in sections, and the pale region underlying

[1] S. F. Harmer, *Quart. Journ. Micr. Sci.*, vol. xxv., N.S., pl. xx. fig. 18.

[2] Hence the name *dodecalophus*.

this indicates the central nervous system. The hypoderm of the basal region contains numerous granular masses (gland-cells and pigment) which have a brownish hue by transmitted light. The plumes (Pl. II.) are nearly of uniform size, and consist of a thickish central stem, occasionally slightly crenate, and furnished with a series of longitudinal fibres ; while distally each is terminated by a peculiar bulbous enlargement, which at first sight resembles the tip of certain hydroid tentacles (*e.g.*, *Coryne* or *Syncoryne*) bristling with dart-cells and pigment. The rugose appearance, however, is due to large gland-cells containing granules and globules (Pl. V. fig. 1), which are arranged in a somewhat regular manner round a central cavity, and which present a deep yellowish tint in the preparations. This structure may perhaps be a further and special development of the somewhat large hypodermic granules of the tips of the pinnæ. The appearance of these bulbous enlargements in section is shown in Pl. IV. fig. 3, part of the upper wall of the stem in this case being formed of the ordinary hypoderm below the tip. When the latter is cut longitudinally, the space in the centre of the bulbous extremity is found to be continuous with a similar space at the end of the arm. Very soon, however, transverse bridles and fibres occupy the central region of the latter, so that a kind of meshwork takes the place of a canal. In transverse section the terminal region of the stem is formed of a thick coating of hypoderm (probably in life covered by a ciliated cuticular layer) somewhat regularly marked (Pl. IV. fig. 4) by striæ so that the cell-like divisions are frequently wedge-shaped. The hypoderm abuts on a basement-tissue, apparently continuous with that which belongs to the basal apparatus next the disk, and which is in relation laterally with the axes of the pinnæ on each side. The wall of the canal of the arm, even in this region, presents a series of fibres which render it hirsute in section, but they do not in every case meet across the lumen. As we proceed downward, however, the sections of the arms are flattened and the margins prominent, so as to form ventral grooves, and the two sides are bound together by transverse fibres, a median junction especially being conspicuous. This meshwork of fibres is better seen in good horizontal and longitudinal sections of the plumes, in which the transverse fibres pass from side to side in almost parallel series, minute nuclei or corpuscles being everywhere abundant, apparently adhering to the fibres, or perhaps indicating their origin from cells of the connective tissue. As in the basal region, therefore, the centre of the arm is composed of a series of reticulations or meshes. The hypoderm also of the arm below the terminal region is considerably thinner, showing that this system of lacunæ reaches its culminating point in the terminal enlargement. The longitudinal fibres inside the basement-tissue are probably those observed in the external views of the arms.

The sides of the stem (Pl. IV. fig. 1) are rendered plumose by a large number of long slender filaments having rounded or slightly bulbous extremities, which show a linear streak from base to apex, from the presence of the axis or skeleton. The latter was first clearly discriminated as a "skeleton" in *Cephalodiscus* by Professor Ray Lankester, for

it had only been indicated as a septum in my preliminary account in the Annals of Natural History. The examination of fresh specimens of *Rhabdopleura* off the Norwegian coast had enabled him to detect the existence of a "consistent mesoblastic skeleton" in the lophophoral arms, as in *Phoronis*, and thus forewarned he had comparatively little difficulty in making out "a precisely similar skeleton" in *Cephalodiscus*. In the latter the so-called "skeleton" of the arms is fixed to the basal apparatus formerly described, and seems to consist of a somewhat firm basement-tissue with longitudinal fibres and reticulations in certain parts. It differs considerably from the condition as figured in *Rhabdopleura*, in which twisted filaments and particles are described by Lankester. The pinnæ which pass out from the main stem do not taper, and are composed for the most part of granular hypoderm with a few brownish pigment-cells, and the central axis or skeleton. The pigment gives in some a light pinkish or pale violet blush to the feathery plumes, which in life must have been finely tinted; and it is further interesting that the same pigment occurs in the lophophore of *Rhabdopleura*, as shown in Professor Lankester's excellent figures.[1] The skeleton (Pl. IV. figs. 1, 2*a*) runs from base to apex and terminates within the cellular tip. It is somewhat dilated where it joins the main stem (Pl. V. fig. 2, *sk*), and the exact mode of its junction with the axial channel of the latter is difficult to trace, so gradually is it merged into the tissues of the region. No definite ending of these axial structures occurs as in *Rhabdopleura*, where Professor Lankester figures them as if articulated to the skeleton of the arm, the base of the pinnules dilating, and the central region abruptly terminating, as it reaches the main stem. The dilated bases of the skeletal rods of the filaments in *Cephalodiscus* join the sides of the reticulated main channel, but no evidence of a continuous central lumen is observed in transverse sections of the free portions, though the double outline, and the appearance of sections of their bases (Pl. V. fig. 2), would indicate the possibility of such. Endosmosis at least would thus readily occur. In the transverse sections of the bases of the processes just alluded to a series of apertures appears in the tissue of the arm. The condition as described in *Rhabdopleura* therefore differs from that in *Cephalodiscus*, especially in regard to the skeleton of the arm, though the general plan of structure is similar. It would also appear to be more readily made out in the former than in the latter, though perhaps this may be partly owing to the examination of fresh examples. Professor Lankester describes the skeleton in *Rhabdopleura* as cartilaginous, but so far as appearances go in *Cephalodiscus* it more resembles a structureless translucent basement-substance, probably a modification of connective tissue. It was best followed in the preparations immersed in a weak solution of caustic potash.

The skeleton of the arms and their pinnules gives a definite character to the processes, as observed in the sketches. Though perfectly mobile, the pinnules stand out from the stem somewhat stiffly, the curves being for the most part terminal, and thus they

[1] *Quart. Journ. Micr. Sci.*, vol. xxiv., N.S., p. 621.

do not mix with each other in an inextricable manner. In the same way the beautiful plumes of the Sabellidæ and *Phoronis* have a certain amount of rigidity from their internal skeleton, while their graceful motions and their branchial functions are in no way interfered with.

No special muscular apparatus can be made out in the pinnules, the covering of the central axis consisting of hypodermic cells and granules. Nor would such be necessary in regard to the physiology of the organs, the elasticity of the skeletal axis and its connection with that of the main stem being sufficient to keep the parts in a position suitable for their functions without any effort on the part of the animal. The main stem has a series of longitudinal fibres, but their muscularity is doubtful. In any case the motions of the disk would influence that of the entire lophophoral apparatus, especially as its great fan-like muscles arise from the skeleton of the basal apparatus of the arms.

The bases of the arms are hollow and in communication with the two great cavities (one on each side) of the region (Pl. VII. fig. 3, *cv*) which Mr. Harmer, on good grounds, identifies with the collar-spaces of *Balanoglossus*. In section the basal spaces are generally filled with fibres detached from the walls, but in some views definite corpuscles in groups are visible. The latter consist of minute rounded bodies with a central nucleus. From the structure of the parts it will thus be apparent that though probably pervious none of the arms show a clear median channel except at base and apex. The paired cavities connected with the lophophoral apparatus communicate with the exterior by a well-marked and comparatively large pore on each side in front of the gill-slits. These pores present a radiate arrangement of the hypodermic wall in transverse section and thus are readily recognised; while in certain longitudinal sections a more or less urceolate aspect is produced.

The tentacles of *Loxosoma* are stated by Professor Vogt and others to be devoid of a central chamber, and the central axis of the same organs in *Pedicellina*[1] is only cellular (and translucent). Even in *Rhabdopleura* careful examination under most favourable circumstances by Professor Lankester gave no indication of a median canal, even in the main stems. He was unable to detect any definite cell-structure in the skeletal tissue, but observed that it had a refringency indicating a certain density, and presented small twisted filaments and particles within its substance at intervals. The relation of the twisted filaments to the fibres described in the main stem of each plume in *Cephalodiscus* is a subject that requires further investigation, and the same may be said of the "particles" which occurred at intervals—in relation to the nuclei already described. Whether *Rhabdopleura* shows any indication of the lacunæ at the base of the lophophore is a question also requiring determination, though if such had existed it could hardly have escaped, in the living animal, two observers of such experience as Sars and Lankester.

[1] *Vide* Nitsche, *Zeitschr. f. wiss. Zool.*, Bd. xx. p. 22, Taf. iii. figs. 1, 2.

The arrangement of these numerous tentacular plumes differs considerably from that in *Rhabdopleura*, in which only two symmetrical tentacular arms with their pinnæ occur. In certain young buds, however, in which the first pair of plumes far surpass the others in length, a striking resemblance is temporarily produced to the condition in *Rhabdopleura*. The latter and *Cephalodiscus* diverge from the ordinary Polyzoa in this respect, both having mobile plumes that curve gracefully in various directions, instead of the somewhat stiffish corona and straight tentacles of the other forms. In *Cephalodiscus*, besides in all probability branchial functions, they are apparently of great tactile service, and if covered with cilia, as in all likelihood they are, they must aid in providing currents in the cavities of the cœnœcium, and, as Sars and Lankester suggest, may indirectly cause food-currents, that is, bring the minute particles which constitute the nourishment of the species within reach of the currents between the buccal shield and the post-oral collar. The efferent currents again would readily find exit by the gill-slits behind the latter lamella. Both *Rhabdopleura* and *Cephalodiscus* differ from the ordinary Polyzoa in the absence of the tentacular web at the base. Both have very long pinnæ; but *Cephalodiscus* excels the other in this respect, and is further characterised by the remarkable glandular tips to the arms. The plumes are wholly absent as such in *Balanoglossus*, and this constitutes a marked distinction externally. As formerly stated in regard to *Phoronis*,[1] however, there are certain evident homologies between the several forms.

Post-oral Lamella.

In *Rhabdopleura* Sars described "a strongly projecting, nearly semilunar border of skin, ciliated on its edges," and extending from the base of the tentacular arms downwards on each side, thus forming with the buccal shield a narrow half-tube or channel leading to the mouth, through which the nourishment is probably conveyed to the mouth by the ciliated tentacles. The condition in *Cephalodiscus*, however, considerably diverges, since the post-oral lamella (Pl. II. fig. 1) forms a flattened apron-like process, fixed anteriorly to the ventral surface behind the oviducts, and sloping along this margin backwards to the mouth, the surface gently merging into the mucous membrane of the oral cavity. Moreover, a central space—more or less distinct according to the line of section—occurs between its layers. Laterally and posteriorly it forms a somewhat free lamella. In minute structure this lamella presents two layers of hypoderm, each with a fine basement-layer, and having intermediate fibres, chiefly muscular. A strong series of these passes out from the basement-tissue of the post-oral mucous membrane, and radiates to the outer (ventral) layer of the lamella, for the posterior or dorsal has merged into the mucous membrane at the sides. The hypoderm of the two surfaces just mentioned offers certain differences, especially in the free part of the lamella (Pl. VI.

[1] *Proc. Roy. Soc. Edin.*, 1880–81, vol. xi. p. 217.

fig. 2, *pl*; Pl. VII. fig. 5, *pl*), that covering the ventral surface being denser and more finely granular, and with a more definite margin, which is probably richly ciliated. This denser and somewhat regularly streaked hypoderm (which also stains more readily) shows several prominent frills or rugæ where it joins the oral region, and it just turns the outer edge of the lamella all round and then ceases. The dorsal layer of hypoderm on the other hand is more lax, and is thrown into a series of frills or crenations in the preparations, the streaks in it being more conspicuous than the granules. It resembles, indeed, the somewhat lax hypoderm observed on the pedicle, and like the latter contains numerous pigment-corpuscles which do not readily stain. So far as the structure can form a guide, the ventral surface would seem to be more important functionally than the dorsal.

The oral region therefore has a different environment from that in *Rhabdopleura*, though the plan of structure follows parallel lines. Thus in the excellent figures of Lankester,[1] a well-marked plate situated behind the mouth, and running into the buccal disk in front of it, is apparently the homologue of this lamella. When the disk is folded backwards (*op. cit.*, fig. 2) the two surfaces come more or less into contact, and would thus send currents more surely into the mouth. Lankester does not allude to this region, which lies just in front of his thoracic division in *Rhabdopleura*. In the flattened surface of the post-oral lamella the buccal shield is closely applied in the preparations, though in life they can of course be separated at will, thus permitting the currents caused by the cilia of the opposed surfaces to reach the oral aperture. As its posterior face has perhaps only to perform the function of separating the currents connected with the mouth from those of the gill-slits, the differences in structure are thus explained.

The post-oral lamella may have some relation to the Molluscan foot, and also to the post-oral ring of cilia in *Polygordius*, especially as a ciliated groove in the latter runs between it and the mouth. Harmer's view that it is homologous with the operculum of *Balanoglossus*, as described in Bateson's valuable and suggestive papers[2] on this form, appears to be well founded.

Digestive System.

Mouth.—The margin of the oral lamella leads on each side (Pl. III. fig. 3; Pl. VI. fig. 2, *m*) into the mouth, and in some ventral views it passes straight inwards to the sides of the latter, and forms a transverse margin anteriorly. The edges of the mouth are slightly raised or frilled laterally and posteriorly, the latter often being spout-shaped.

[1] *Op cit.*, pl. xxxviii. figs. 1, 2.

[2] *Quart. Journ. Micr. Sci.*, April 1884; also Studies from the Morph. Lab. Univ. Camb., vol. ii. part i., and vol. iii. part i. The author has overlooked some remarks previously published in this country on *Balanoglossus*. *Vide* Nemerteans, *Ray. Soc.*, 1873, p. 144.

Anteriorly it is devoid of any well-defined boundary other than the attachment of the pillar of the great buccal shield, and leads directly upwards into the alimentary canal (Pl. III. fig. 1, *m*). Moreover, as Mr. Harmer first noticed in his sections, a solid diverticulum proceeds upwards dorsally into the stalk of the buccal shield, and this may fairly be held to be the homologue of the notochord of *Balanoglossus*. In transverse section it is nearly circular and presents a somewhat regular arrangement of its cells, so that a concentric appearance is frequently present. In longitudinal section, on the other hand, the process, which is small, has a slightly bent clavate outline, a dotted axis indicating the lumen continued from the alimentary canal. The mucous membrane of the buccal chamber and gullet are thrown into many prominent rugæ, from the dense glandular nature of the tissue. The latter is especially thick on the ventral side of the mouth (the region lying in front of the post-oral lamella), and a strong layer of muscular fibres passes to the basement-tissue of this region, which must thus possess considerable mobility. The surface of the mucous membrane is apparently richly ciliated, the cylindrical epithelium of which it is composed being so closely arranged as to give a finely striated character to the tissue. In some preparations a thin film occurs on the surface of this glandular layer, but this is evidently due to mucus, and not to the separation of a superficial or cuticular coat.

Pharyngeal Region.—Beneath the post-oral lamella and immediately behind the pores of the second region are a pair of gill-slits, which were first clearly recognised as such by Mr. Harmer, who has kindly interested himself in the structure of this form, and whose very thin sections enabled him to unravel certain points which would otherwise have been obscure. The folds leading to these in transverse section are shown in Pl. VI. fig. 2, *gs*. Immediately behind the collar-pores the ordinary hypodermic coating of the body becomes continuous with the translucent wall of the slits, which seems to be a modified continuation of the pharyngeal mucous membrane. The granules are finer, and the whole tissue is more translucent. It also does not stain so well as either the collar-pores or the pharyngeal lining proper. In connection with this structure it is interesting to note that Bateson[1] mentions that the gill-slits in *Balanoglossus* arise as dorso-lateral evaginations. As soon as the posterior boundary of the mouth is completed, and this is easily recognised in the preparations by the appearance of the pigment-cells in the dorsal layer of the hypoderm of the post-oral lamella as it now stretches right across the ventral surface, the spacious pharynx presents a thickly folded wall of the same kind of minutely glandular tissue. The projection of some of these thick folds of glandular tissue under the post-oral lamella, sometimes causes peculiar appearances in transverse section, as if special diverticula existed. Bounding this thick glandular wall externally is a firm basement-layer, probably of a highly elastic nature, and it is to this coat that the muscular fibres formerly alluded to are attached.

[1] *Op. cit.*, p. 14.

Œsophagus.—The firm and finely glandular œsophageal region (Pl. III. fig. 3, a little behind *œ*), which is characterised by the paucity of its folds, is comparatively short, for it merges into the gastric chamber a little behind the termination of the buccal shield (Pl. III. fig. 3).

Stomach.—The stomach forms a large cavity, which in some instances fills the whole of the body-space, with the exception of the dorsal area occupied by the intestine. In certain longitudinal sections the œsophagus forms a comparatively limited tube, while the stomach fills the entire body-cavity (Pl. III. fig. 3), but dorso-ventral flattening of the former may have occurred in such cases. The wall of this region is also somewhat thick, and when fully formed, is distinguished from the œsophageal region by its more numerous and often symmetrical folds, and sometimes by a differentiation into three pseudo-strata, viz., a deeply stained, granular, epithelial, superficial layer marked by close parallel striæ, a pale intermediate region with granular glands, and externally another deeply stained stratum of granular glands. It is not implied that there is separation in continuity between the three regions indicated, but rather that either from preparation or otherwise such a condition appears in the stomach. The colour of this region in life is probably as characteristic as in *Rhabdopleura*, where it is yellowish, but this feature cannot be made out in the spirit-specimens, for all are bleached. In the preparations it not unfrequently happens that rupture of the alimentary wall occurs along the middle region, so that the complexity of the folds in the body-cavity is increased. Externally the whole organ is surrounded by a firm basement-layer continued from the œsophageal region, and from its elasticity this probably subserves certain of the functions of a more elaborate contractile apparatus, for muscular fibres have not been clearly determined. The chamber narrows posteriorly towards the pedicle, and terminates in the intestine, the glandular wall, however, undergoing no change of note.

In *Rhabdopleura*, Sars[1] mentions that the stomach has tolerably thin walls, but in all probability he speaks comparatively, as from the nature of the glandular tissue such organs have proportionally thick walls.

Intestine.—As in *Rhabdopleura*, the stomach terminates at the posterior end of the body-cavity at the base of the pedicle by a wide aperture in the intestine. In favourable sections (Pl. III. fig. 3) the intestine is observed to leave the ventral side of the fundus of the stomach, and passing under it, curve forwards along the dorsal wall. The glandular lining of the ventral wall of the stomach passes evenly into the intestine and gradually diminishes in thickness, whereas the lining of the posterior wall shows a characteristic bend at the pylorus, and again a fold in the anterior wall of the intestine behind the fundus (Pl. III. fig. 3, near *vtd*). This peculiar fold in the wall of the canal probably indicates a tendency to the formation of a second or pyloric stomach, as in *Phoronis*, and is therefore of considerable morphological significance. The intestine

[1] *Op. cit.*, p. 5.

acquires its narrow firm texture even before taking the forward curve along the dorsal wall. The gut forms a somewhat large canal, which proceeds along the dorsal wall above the stomach to terminate on the anterior prominence of the body in the anus, which lies considerably above the region of the plumes, and, indeed, the area in which the large pigment-spots are situated intervenes. There is thus a decided difference when the anal region is contrasted with that in *Rhabdopleura*, in which the anus is situated close to the base of the tentacular arms on the dorsal side of the animal, that is, on what Sars terms the posterior region. Lankester, however, in his figure[1] shows the anus elevated on a rectal cone, with a depression between it and the base of the lophophoral region; and, moreover, on the lateral and ventral faces of this cone isolated blackish pigment-corpuscles are present. No rectal cone is present in *Cephalodiscus*, for the prominent anterior end of the body carries the anus on its summit. It has the form of a more or less elliptical aperture, often of considerable size. The minute structure of the wall of the intestine differs considerably from that of either gullet or stomach by its well-defined boundary-line—both externally and internally. The external consists of the firm basement-layer, which ventrally invests the stomach, and which at each side of the usually elliptical or transversely elongated gut (in section) runs into a thinner basement-layer bounding the canal dorsally within the proper wall of the body. The granular glandular coat which follows is narrow, and is limited internally by a remarkably definite margin in section, so that the canal is at once distinguished in the preparations. In Professor Lankester's section[2] of the intestine in *Rhabdopleura*, no such compact and definite wall is observable, the gut apparently being enclosed by a somewhat moniliform layer of cells. This divergence in structure doubtless indicates difference in function, probably in relation to the free and the fixed conditions of the respective animals. The terminal region of the gut (or rectum) frequently shows considerable dilatation, the indigestible debris being probably sent out at intervals in a stream, and it is this deposit which is occasionally found in certain crevices of the cœnœcium.

Food.—A survey of the fine muddy debris found in the alimentary canal, and especially in the intestine, shows that the currents—set up in the surrounding water by the plumes, and conveyed towards the oral aperture by the ciliated surface of the post-oral lamella and the great buccal disk—carry inward, amongst indigestible sponge-spicules and sand-particles, many Diatoms, bodies resembling minute Thalassicollidæ and other Radiolarians, as well as organic particles of various kinds. When large forms like the Ascidians flourish on a diet composed largely of Diatoms, it is evident that this minute type is amply cared for in this respect. The honeycombed condition of the cœnœcium,

[1] *Op. cit.*, pl. xxxviii. fig. 2, *b*, and pl. xl. fig. 11, *e*.
[2] *Op. cit.*, pl. xli. fig. 13, *h*.

and the multitude of external apertures, thus suffice to place the little ciliated animals in favourable circumstances as regards food, especially when the nature of their surroundings is taken into account.

Body-Wall.

In *Rhabdopleura* two layers of the body-wall were clearly distinguished by Professor Allman, who had not the material aid which sections give the younger inquirers. He called them ectocyst and endocyst, the latter "a very delicate membrane." Professor Sars, subsequently, with fresh specimens at his disposal, denied that there was any endocyst "(unless we consider the glassy skin, which closely surrounds the digestive apparatus, to be an endocyst), consequently also no perigastric fluid." Professor Ray Lankester, again, from the examination of living examples, recently observes of *Rhabdopleura* that "the tissue which bounds the body-cavity consists of fusiform cells tapering into fine fibres, sometimes branched." He further figures the structure of the body-wall in optical and in transverse section, the coat formerly mentioned having within it apparently a basement-membrane with ciliated enteric cells projecting from its inner surface. In whatever way this form is considered, the structure of its body-wall very much differs from that of *Cephalodiscus*.

I am unable from the mode of preparation of the examples (in spirit) to say much about the pigment of the surface of the skin, but in some numerous specks of a reddish-brown colour are still visible over the entire surface (Pl. II. fig. 1); while, as already mentioned, the buccal disk almost always presents the dull reddish band. In all probability it is brightly tinted in life. In this respect it approaches the condition in *Balanoglosus*; thus *Balanoglossus kowalevskii* has a white proboscis, a brilliant red-orange collar with a whitish line round the operculum, while the rest of the body is orange-yellow.

Externally the surface is probably covered in life by a delicate ciliated cuticle, but this cannot be differentiated in the preparations. The same difficulty is met with in the cuticular tissues of the Nemerteans. A decided difference is thus apparent between *Cephalodiscus* and *Loxosoma*, in which the cuticle is considerably developed. What remains is a well-marked layer of hypoderm (Pl. VI. fig. 2, *hp*) of the usual granular, glandular structure. The coat just mentioned attains its greatest thickness at the base and on the pedicle, but this may be partially due to corrugation from contraction. In this layer are the numerous pigment-corpuscles and gland-cells, which latter do not readily stain with carmine. It is bounded internally by a basement-layer, which is thin dorsally, but better marked ventrally, especially behind the mouth, for the layer of longitudinal muscular fibres now forms an additional coat in this region, and rests against the basement-layer. Like the hypoderm the latter passes over the pedicle at the posterior end of the body, and both are often thrown into wrinkles from contraction. The body-wall

is further strengthened ventrally by a muscular layer, but this will be described under its special head. The preparations showed traces of what might be an epithelial layer on the inner surface of the before-mentioned basement-tissue, but such were far from being distinct. In the living *Rhabdopleura*, on the other hand, such an epithelial layer is described by Professor Lankester, under the name of "enteric epithelium," and its distinctness in this form suggested its presence in *Cephalodiscus*.

Body-Cavity.—The foregoing layers enclose the body-cavity (*co* in sections of buds), which is generally filled more or less completely by the alimentary canal. In the preliminary account[1] it was pointed out that this investment was probably homologous with the "thin glassy skin" of Sars surrounding the digestive canal in *Rhabdopleura*, and that the preparations gave no evidence of perigastric fluid. Though the existence of a body-cavity was not specially noticed, the preparations did not warrant a denial of its presence in *Cephalodiscus*, as Professor Lankester states in a recent paper,[2] for thus the hypoderm and basement-tissue must have been amalgamated with the coat of the alimentary canal, which was not the case. This statement does not in any way detract from the credit which Lankester has in clearly describing for the first time the chamber in the living *Rhabdopleura*. Small nucleated corpuscles were occasionally seen in groups in the cavity of *Cephalodiscus* in the sections, but they may have been introduced from other sources. Neither Sars nor Lankester observed such in the living *Rhabdopleura*. In sections the continuation of the body-cavities in front are seen a little behind the paired cavities connected with the lophophoral apparatus, and are likewise surrounded by basement-tissue.

Muscular System and Pedicle.

As previously mentioned, the short ventral surface of the body is continued into the cylindrical pedicle, which is invested by the hypoderm and basement-tissue, the former being thrown into numerous and rather regular transverse wrinkles in contraction, and being thicker dorsally than ventrally. At the terminal region of the foot (Pl. VI. fig. 1, *hps*) the hypoderm is much increased in thickness, but has the same structure. It is free from the wrinkles which characterise other parts of the region; and appears indeed in favourable preparations to form a flattened sucker-like disk. The basement-layer within the terminal hypoderm is thick, and has attached to it the longitudinal muscular bands, so that it is possible it may be occasionally used as a sucker like that of *Loxosoma*, or like the larval organ in *Balanoglossus*. The entire pedicle within the basement-tissue is filled with the longitudinal fibres, which arise on the ventral wall of the body in the region of the mouth, where they present the form of a thinner lateral region and a denser central, the latter in

[1] *Op cit.*, p. 344.

[2] Polyzoa, Ency. Brit., vol. xix. p. 436.

the sections being somewhat semicircular and of considerable thickness. These fibres pass backwards (causing the ridge on the ventral surface in contraction) towards the pedicle, which they enter, filling the central space. In transverse section the appearance of the latter varies, but in the best preparations a certain uniformity is observable (Pl. IV. fig. 5), viz., beneath the smoothly rounded hypoderm a median fold occurs in the basement-tissue dorsally, while a much larger and wider one occurs ventrally, and at each side of this an inner longer and an outer shorter process exist. The whole has a symmetrical appearance. Such an outline would indicate that the basement-tissue was elastic and that no circular muscular fibres existed, and indeed from the descriptions of Vogt and other authors similar elastic tissues subserve the function of circular fibres in *Loxosoma*. In some sections of unstained examples the thick basement-tissue had a somewhat different aspect (Pl. VII. fig. 2), probably from the condition after immersion in spirit; this, however, was exceptional. A layer of fine longitudinal fibres lies on the inner surface of this coat, and from it numerous transparent and somewhat gelatinous fibres of connective-tissue pass to the central area, which contains large structures deeply stained and almost resembling gland-cells, but which appear to be sections of the long mobile muscular fibres continued from the fundus of the body into the pedicle. The close approach made by these to the "muscular band of closely-set fusiform cells" described by Lankester in the stalk of *Rhabdopleura* is noteworthy; they probably represent a further development of that tissue—in which the cells have disappeared. A similar series of muscle-cells in the stalk is described by Harmer in his valuable paper on *Loxosoma*.[1] In contraction the transverse wrinkles of the basement-tissue are so close that they resemble a circular muscular coat.

No distinct canal is thus observed in the centre of the pedicle throughout its length. Towards the tip, however, certain spaces containing what appears to be a coagulable fluid occur, and also globules and granules; as explained in connection with the buds.

The pedicle in *Cephalodiscus* is thus evidently a development of the body-cavity, which in the young bud freely opens into its upper region. It differs, therefore, from the soft stalk of *Rhabdopleura*, first so clearly described by Professor Allman, for that has no connection with the body-cavity in the adult; yet as the development of both forms is unknown a little reservation is necessary, especially as it also contains muscular fibres in *Rhabdopleura*, and gives rise to the buds and branches. The fibres of the stalk in *Rhabdopleura*, according to Professor Sars, proceed "rather high up on the ventral side," and "over the skin which encloses the digestive apparatus. Its ventral fibrous part may still be traced (see fig. 15) a considerable distance forward in the form of a rather wide, clear, skin-border which gradually disappears in front of the cardia. In this skin-border the fine longitudinal fibres may still be distinctly observed diverging like radii, but I was not able to trace their course further."[2] The arrangement of the parts

[1] *Op. cit.*, p. 19.

[2] *Op. cit.*, p. 10.

in *Rhabdopleura* has also been carefully figured on a larger scale from life by Professor Lankester.[1] There are thus interesting points in analogy between the two forms in regard to the polypide-stalk, but at the same time important structural differences.

Professor Lankester again holds that the chitinous covering (his Caulotheca) of certain parts of this region is the true homologue of the cœnœcium of an ordinary Polyzoon, and there is something to be said in favour of such a view. As already explained, however, I prefer to adhere to the term already in use, especially in the present uncertainty in regard to the development of the types under consideration. Nor do I fully share my friend's views concerning the "serious error" of confounding the pedicle in the forms just mentioned with the funiculus of the Eupolyzoa. The structural relations of the organ in the several forms no doubt differ, but the remarkable analogy in regard to the budding shows that from the "vagrant protean funiculus" of the Gymnolæmatous Ectoprocta to the pedicle and soft stalk of *Cephalodiscus* and *Rhabdopleura* there is at least one striking function carried out often on very similar lines. Variations, it is true, occur, in which the endocyst is associated with the funiculus in producing the buds in the marine Ectoprocta, but this does not affect the main point at issue, but rather brings the analogy closer with such forms as *Cephalodiscus*.

The pedicle on the other hand nearly resembles the stalk in *Loxosoma*. There is no pedal gland, however, in *Cephalodiscus*.

One of the most remarkable points of resemblance between *Cephalodiscus* and *Balanoglossus* is the occurrence of a pedicellate structure in the young of the latter (*Balanoglossus kowalevskii*) as described by Mr. Bateson.[2] This organ presents itself on the disappearance of the cilia as a small papilla, and is situated at the central part of the posterior surface. Moreover, it is directed ventrally, just as the pedicle of *Cephalodiscus* is, and, indeed, the general contour of the young form at this stage simulates the condition in *Cephalodiscus*. This conical process serves as a sucker by which "the animal can attach itself to foreign bodies sufficiently firmly to prevent being washed off by a stream of water from a pipette. The anterior surface of the proboscis is also slightly suctorial, and by thus fixing itself posteriorly, and extending the proboscis, it is able to creep slowly about, somewhat in the manner of a leech." The organ "subsequently attains a considerable size and is traversed by several wrinkles. It afterwards entirely disappears, but as to its mode of disappearance I have no certain observations. It would appear to occur very suddenly at the stage when the animal possesses seven to eight gill-slits. I have found animals with eight gill-slits which possess this sucker, and also animals of apparently the same age without it; hence it may be inferred that it undergoes a rapid atrophy at this point." Mr. Bateson further observes that similar suckers occur as larval organs in Tunicata, Ganoids and Amphibia, but these fall far short of the

[1] *Op. cit.*, pl. xl. fig. 12.

[2] *Quart. Journ. Micr. Sci.;* and Stud. Morph. Lab. Univ. Camb., vol. iii. part i. p. 3, pl. i. figs. 1–4, 1886.

interest connected with the condition of the permanent pedicle in *Cephalodiscus*. This is a truly homologous process of the posterior body-cavities, and in sections at the base, as already explained, the septum is visible (*vide* Pl. V. fig. 4). It is further placed ventrally in regard to the intestine, and its tip, so far as structure shows, is in all probability also used as a sucker; indeed, the buccal shield and the tip of the pedicle form far more efficient and permanent sucking disks than ever occur at any stage in *Balanoglossus*. It is the disappearance of the "tail" in the latter which alters the character of its reproduction, and confines it so far as known to the sexual process. The presence of this organ in *Cephalodiscus*, again, and its striking activity in bud-formation, open up new fields in homology and assist in bridging over the gaps which formerly existed between apparently isolated groups.

Nervous System.

In the preliminary account of *Cephalodiscus*[1] no distinct nervous system was observed. In *Rhabdopleura* all that the careful observations of Sars could distinguish in regard to a nervous system was that "immediately behind the anal aperture, between the terminal part of the intestine and the dorsal wall of the gullet, which here forms a little concavity, there appeared a clear cellular body (fig. 15, *r*) in which several evident nuclei were visible. I cannot, however, pronounce any decided opinion as to the significance of this object; it can scarcely be a nervous ganglion, as it does not lie in the substance of the body itself, but only in the thin external skin which encloses the body." Lankester, again, considers that it is probable that the "clear cellular body" just mentioned by Sars was a gonad. It is doubtful, however, whether the latter interpretation can be maintained, especially when the condition now known in *Cephalodiscus* is considered. At the base of the plumes in the latter, and situated over the median space existing there—above the mouth—is in section a region (Pl. VI. fig. 3, *nc*; Pl. VII. fig. 3, *nc*), which appears to me to contain the central nervous system of the animal. The area is of considerable proportional size, and is minutely cellular and granular, while fibrous bands stretching from it occur in other views. Its inner face rests on the thick basement-layer bounding the collar-spaces at the base of the arms, and to the opposite wall of which the muscular fibres of the great buccal disk are attached; while its outer covering is formed by a thick layer of hypoderm. This region forms an elevation dorsally between the bases of the arms (Pl. VI. fig. 3, *nc*), and thus is in close communication with these organs, while it is also within a short distance of the pigment of the oviducts, though no branches have been traced to these organs. It extends a considerable distance laterally on each side along the basal region, whence the plumes spring, and for some distance on the dorsal surface of the buccal disk. The relations of the nervous system to

[1] *Ann. and Mag. Nat. Hist*, ser. 5, vol. x. p. 337, 1882.

the rudimentary notochord will be specially referred to by Mr. Harmer in a note appended to this paper. The view of Professor Sars that this structure cannot be a nervous ganglion, because it does not lie in the substance of the body, would not seem to merit the importance he attaches to it, when the condition of the great nerve-cords and ganglia of Annelids, for instance, are considered. These are purely hypodermic in position, lying between the latter and the basement-layer beneath.

In *Phoronis*, again, a somewhat similar condition to that in *Cephalodiscus* is present, the nervous concentration taking the form of a ring round the mouth at the bases of the tentacles, and this, like the cord running along the foot, is epidermic (hypodermic) in position.[1] The same position (hypodermic) of the nervous system is found in *Balanoglossus*, so that the relations of the nerve-centre are by no means exceptional.

The position of this nervous centre would not appear to correspond with the larval brain of *Loxosoma* as described by Mr. S. F. Harmer. In the stalked or adult *Loxosoma*, again, the ganglion is subœsophageal, and is therefore not the homologue of the larval brain. A very different condition, however, occurs in *Cephalodiscus*, in which the young buds soon present this and all the other organs of the adult, although it is true the development and perhaps metamorphoses of the species from the egg are unknown. It has also to be borne in mind that certain parts of the central nervous system may have been suppressed, and that we may have only a much modified peripheral system remaining.

Sense-Organs.

In the preliminary account of *Cephalodiscus*, the close relation of the so-called "eye-spots" to the ovaries was duly pointed out, and recently the examination of more satisfactory sections made with a microtome demonstrated at once their true nature; viz., that they are oviducts with thick pigmented walls. The resemblance of these structures, both externally and in section, to a modified organ of sight, is one of the most remarkable features in the animal. Their description will be given subsequently.

In *Rhabdopleura*, Lankester mentions the occurrence of five spherical pigment-corpuscles at the superior dorsal margin of the buccal disk, and regards them as rudimentary sense-organs for the perception of light. The position of these is certainly peculiar for organs of vision, but if *Rhabdopleura* has a trace of the central nervous organ observed in *Cephalodiscus*, these would readily be within reach of its communications.

It is interesting that eyes occur in most larval forms of *Loxosoma;* indeed, they make their appearance when the larva is still in the egg. They are situated under the hypoderm, and resemble pigment-masses. In *Loxosoma leptoclini*, for instance, Harmer describes a pigment-spot on each side of the larval brain (even when the lumen is still present after involution). They consist of crescentric reddish-brown masses of pigment, with a

[1] Caldwell, *Proc. Roy. Soc.*, vol. xxxiv. p. 372.

prominent lens, but whether the latter is a solid body, a cuticular formation, or only fluid in the centre of the mass, is not explained. Mr. Harmer bases one of his arguments for the interpretation he has given of the "dorsal organ" (brain) on the constant relation to each other of ganglion-cells, a fibrous layer and the eyes, and he seems to have facts in his favour.

In *Rhabdopleura* a ciliated tubercle (considered by Lankester and others to be a sense-organ) was discovered by Sars on the dorsal surface at the base of each arm of the lophophore. In *Loxosoma* Vogt[1] also describes a tactile papilla on each side near the arms, and Salensky[2] traced nerves from the ganglion to these posterior sense-organs in *Loxosoma crassicauda*. No such organs, however, can be observed in the preparations of *Cephalodiscus*; though it is possible the search in the living animal may be more successful. The oral folds of glandular tissue and the parts connected with the gill-fissures are probably highly sensitive and ciliated, but no other sense-organs could be observed.

Reproductive Organs.

No differentiation was noticed in regard to the sexes, and no dimorphism of the zoids, as in Professor Ehler's remarkable burrowing form (*Hypophorella expansa*[3]). Nothing is more striking, however, than the profusion of buds and the abundance of ova, apparently one of the chief ends of the species being propagation. The chambers of the cœnœcium present many of the large ova, and they are occasionally found amongst the plumes, as in *Phoronis*, with its swarms of minute eggs; but such in the former is probably accidental. Almost every adult again bears one or more buds attached near the tip of the pedicle.

Ovary.—In most specimens a pair of large ova are observed projecting anteriorly (Pl. III. fig. 2, *ov*), so that their pure white colour is recognised through the attenuated integument above and behind the eye-like oviducts, which, as it were, mark the anterior boundary of the ovary. In section it is found that a septum passes from the median wall of the rectum to the opposite wall of the body, thus dividing the body-cavity in that region into two spaces, in which are the ova supported on a pair of lateral mesenteries. As soon as the glandular tissue forming the dorsal wall of the buccal cavity appears, the mesenterial septum just indicated is attached to its basement-layer externally, and also more or less in the median line. The septum disappears on the approach of the stomach, or about the posterior termination of the great buccal disk, and any product remaining towards the end of the latter is generally pushed to one side. As a

[1] Sur les Loxosoma des Phascolosomes (sep. copy), p. 8, pl. xii. fig. 1.
[2] *Ann. d. Sci. Nat.* (Zool.), sér. 6, t. v. p. 12 (art. 3), pl. xii. figs. 2, 3.
[3] *Abhandl. d. k. Gesellsch. d. wiss. Göttingen*, 1876.

rule, one of the spaces anteriorly contains a group of small ova (Pl. VI. fig. 2, *ov*), with nucleus and nucleolus. In the smallest ova observed the nucleus is very distinct, and of a more or less rounded form—with a large nucleolus. The yolk outside the former is minutely granular, and sometimes, to judge from the preparations, does not quite fill the egg-capsule. As the eggs increase in size the yolk-granules become somewhat more distinct, the nucleus being large and rounded, and the nucleolus a highly refracting circular body of considerable size. Moreover, as they increase they tend to move away from the smaller ova, and indeed bulge outwards on the opposite side. The largest ova, of which, as a rule, there is but one, are much more coarsely granular, and present only a nucleus with minutely granular contents, the nucleolus having disappeared or having become very indistinct. The capsule surrounding each of the eggs is definite and tough, and the eggs are further enveloped by a common layer, which in all probability is allied to the follicular layer in fishes and other types, and this dips between each, apparently enclosing the ova in separate chambers. The ova are probably extruded through the oviducts with the pigment in their walls, and it is noteworthy that, as Mr. Harmer has specially pointed out to me, no pigment is visible in young individuals in which the ovaries are not yet functional. There is thus an approach to the condition in *Loxosoma* in this respect, for the latter has oviducts for conveying the ova into the vestibule. The same may be said with regard to *Phoronis*, though in this the so-called nephridia lie on the other side of the intestine.

The comparatively large size of these ova recalls the condition in the Arctisca, in which the great ova produce embryos about a third the size of the adult.

Oviducts and Pigment.—On the ventral surface are two large and conspicuous pigment-spots, which as already mentioned closely resemble eyes (Pl. III. fig. 1): they indeed give a most peculiar and characteristic aspect to the animal when viewed from the ventral surface. These are placed a little in front of the anterior margin of the post-oral lamella, and in ordinary preparations are more or less covered by the buccal disk. They are circular or irregularly rounded, and of various shades of brown or reddish-brown, with occasionally a tinge of violet. In ordinary views from the exterior these organs show a pale centre surrounded by a broad margin of pigment, so that the former assumes the aspect of a lens (Pl. VI. fig. 2, *od*). In section the hypoderm in the central region is hollowed more or less deeply, and its wall presents a finer, columnar arrangement of its cells, and, in addition, it is almost, if not quite, transparent. Moreover, an aperture exists in the centre, as already mentioned. In shape the ducts have the form of a blunt cone, the apex of which abuts on the modified hypoderm, while its base rests on the small anterior ova. The pigment-cells form a thick layer; their inner pale portions projecting internally, so that their resemblance at first sight to an optical apparatus is remarkable; yet Dr. Marcus Gunn, who kindly examined them in a special manner, could discover no refractive mechanism.

Nothing intervenes between their cavity and the ovigerous envelope, and indeed, as formerly stated, they are so closely related that they are generally removed together in dissection. No nerve-fibres could be traced from the central apparatus to these organs, though appearances were favourable to such a view. Mr. Harmer, who independently arrived at a similar conclusion with regard to the function of these organs, thinks the pigment of an excretory nature. When the life-history of this peculiar form is more completely marked out, it is possible that these oviducts may be found to be light-producing organs.

On extrusion the ova (Pl. V. figs. 5, 6) are pure white, and either pyriform or rounded in shape. Each is provided with a well-formed pedicle of the transparent investment, truncated at the extremity for attachment. The diameter of the circular kind is about 0·55 mm., or including the short stalk 0·63 mm. In the more pyriform or longer forms the total length (including the stalk) is about 0·7 mm., and the transverse about 0·5 mm. The diameter of the contained yolk is about 0·36 mm. in the former kind, and in the latter is nearly of the same proportional size, though more ovoid in outline. A large space (perivitelline) existed around these eggs, but whether endosmose had occurred after deposition, or otherwise, is at present unknown. The capsule is hyaline and structureless, presenting only a few wrinkles at the base of the stalk, which is hollow and truncated at the tip. The opaque white central region is coarsely granular, as in the intra-ovarian eggs. Each is attached to the wall of the chamber of the cœnœcium by the pedicle, though as now seen, that is after the action of spirit, many have become detached.

The products of the foregoing ova are yet undiscovered, though in all probability they are motive embryos which carry the species to fresh sites on which to construct the cœnœcium. Such embryos had all been swept out of the chambers either before or after capture, as no trace of them could be found in the preparations.

The reproductive organs seem to be more largely developed in this genus than in *Rhabdopleura*, none indeed having been found in the latter by its discoverer, Professor Allman, or subsequently in the living examples by Professor Sars. Professor Lankester, however, was successful in finding a testis in "the form of a much elongated sac ending blindly at one end and opening by the other to the exterior by a special pore." The latter occurs near the anus. The position of the aperture of the male generative system thus probably indicates what will be found in the living *Cephalodiscus*, and it is possible that the male organs are developed at a different period from the female in the same animals, or that the males exist in separate colonies. In some of the sections of the reproductive organs minutely granular masses like sperm sacs were occasionally seen, but further examination gave no grounds for supposing that they were anything but imperfectly preserved contents of the ovaries.

Budding.

No feature is more striking in this species than the great abundance of buds throughout the entire series of adults inhabiting the cœnœcium. Very few exist without them, most presenting from one to three or more buds at various stages, and in all cases these proceed from the terminal region of the pedicle.

The early buds consist of minute and, in the preparations, somewhat pale clavate or pyriform bodies attached by the narrow end to the pedicle. They are situated round or near the tip (which has the thickened investment), and are observed as little processes projecting from the hypoderm. They appear to rise close above the terminal disk, and, in their earlier stages at least, seem to have a channel of communication with the pedicle of the adult (Pl. VI. fig. 1, *ch*). This channel runs upwards along the stalk of the bud as far as the downward bend of the hypoderm (shield) where it is lost. In the earlier buds longitudinal sections, for an examination of the best of which I am indebted to Mr. Harmer, show very clearly the three regions of the body, viz., shield, nuchal region and body-proper, and each has its special spaces. Thus the shield presents its single cavity, the nuchal or collar-region its paired spaces, and the third region contains the body-cavity divided by the mesenteries (dorsal and ventral).

Very soon the pedicle is differentiated from the disk; the young animal consisting of a large, flat, and somewhat thick disk, and a short, broad, and somewhat crenate pedicle attached to the parent. Two ovoid opaque thickenings are observed about this stage dorsally (Pl. V. fig. 3, *lp*), and these are the earliest indications of the lophophoral plumes. In cross section from above downwards the shield consists of a thick layer of hypoderm which attains its greatest development ventrally, for this coat is in the form of a flattened ring round the central chamber. The latter is bounded by a firm investment of basement-tissue having fibres internally. It is this chamber in the younger forms that communicates with the pedicle of the adult. The two dorsal bosses are simply hypodermic growths of the upper layer of the shield, and present an elevation between them.

At a somewhat lower level the elongated cavity in the centre of the shield gives place to a rounded median chamber (Pl. V. fig. 3, *vc*), with the dorsal hypodermic mass above it; while the great bosses of the plumes lie on each side. The latter still present the same structure as the hypoderm of the buccal disk, though there is a faint indication of a linear streak in the centre. In the next slice the two nuchal or collar-spaces appear, with the alimentary canal in the centre. In the septum, between the collar-spaces, the tip of the notochord is observed, and it appears to be larger proportionally in the young than in the adult. The basement-tissue bounding the nervous centre is now defined, and the shield and bosses are diminishing. Behind this the folds of the alimentary canal fill the central region of the body, the intestine being especially distinct as a median canal, the longest axis of which is directed ventrally instead of being transverse

as in the adult. Posteriorly the body presents, firstly, two lateral chambers with fibres internal to the basement-layer, and secondly, a median (dorsal), with a process of basement-tissue running to the ventral line, and forming the septum between the two former. The pedicle seems to be filled with muscle-cells.

In the terminal region of the pedicle of the adult certain areas containing a coagulable fluid with globules and granules are present, and occasionally in the elevation caused by a developing bud one or two of them are observed; and they are also seen in the buds here and there in the course of the central muscles of the pedicle. Some appear to be nucleated. The origin of these bodies is unknown, but they may be connected with the mesoblastic or hypoblastic elements for the buds, though this is only a conjecture. In regard to the presence of the three primary embryonic elements, as a rule, in such buds, the remarks of Professor Haddon[1] seem to me to be very interesting, but they have yet to be proved. The doubt remaining in the present case, for instance, relates to the precise nature of the hypoblastic elements. In connection with this subject it is well to state that some observers, as Mr. Harmer, demur to the connection of the latter layer with the origin of the buds.

As development proceeds, the anterior or disk-bearing region of the body increases much more in proportion than the posterior or pedicellate part. The buccal disk is rapidly enlarged, and shows traces of the broad arch of pigment anteriorly and the reddish band posteriorly, as well as the two median elevations on the surface. The posterior moiety of the disk is especially large. Moreover, the body begins to project outward superiorly, and the papillæ of the plumes increase in number. These papillæ form a slightly curved row in front of the dorsal projection of the body (woodcut, fig. 2).

In the next stage the disk is almost completely formed, though of smaller size and more massive than in the adult. It is thickest anteriorly, much thinner posteriorly. In the former region it presents in transverse section the elongated central chamber, bounded ventrally by the massive hypoderm of the shield, which has the two median prominences observed in the adult. This hypoderm folds over at each side, and is continued as a thinner stratum dorsally, with a basement-layer next the chamber. Two additional structures have now appeared, viz., a dense (narrow) layer outside the basement-tissue just alluded to, and fan-like fibres from the middle of the dorsal wall of the chamber. Two of the most ventral plumes (the first to appear) have now attained some size, the tip being furnished with the radiate terminal glands having the central chamber, and the sides with short papillæ representing the filaments. Both the latter and the axes of the plumes are composed of hypodermic tissue, and are apparently solid. Longitudinal striæ are visible along the centre of the axis, and they run into the lining of the cavity in the terminal enlargement. Then the central chamber appears dorsally

[1] *Quart. Journ. Micr. Sci.*, N.S., vol. xxiii. p. 34, 1883.

in the middle line (Pl. V. fig. 3, *vc*), and the fibres to the ventral wall of the shield radiate from the basement-tissue. Dorsally several less developed plumes also make their appearance (Pl. VI. fig. 4), and the pale (nervous) area lies under the hypoderm. Next the two nuchal chambers take the place of the former, and the hypoderm over the median nerve-area increases much in thickness, the whole forming a somewhat triangular region between the bases of the plumes, which are thus carried outwards. None of these plumes are so well developed as the first pair. While the nerve-area retains a large size, with the two chambers and the fan-like fibres ventrally (Pl. VI. fig. 5), the knife now severs the anus, which at this stage lies close behind the massive dorsal hypoderm of the nerve-area. Then the glandular wall of the buccal chamber and the post-oral lamella appear, while the body-cavity on one side of the rectum presents a granular mass (Pl. VII. fig. 4, *ov*), the rudiment of the ovary. The great buccal disk becomes much broader as well as thinner, and is solid, while a central chamber appears in the post-oral lamella. The body-cavity is much better marked in the young forms than in the adults, and just behind the mouth (Pl. VII. fig. 5, *r*, *vt*, *oe*) has in section a symmetrical arrangement of the gullet, stomach and intestine, the body-wall showing the basement-layer beneath the hypoderm. The pharynx, gullet and stomach are rounded or ovoid in transverse section, but the intestine is triangular. The longitudinal muscular fibres appear along the ventral wall immediately behind the mouth, and soon form the marked pattern so characteristic of the region (Pl. V. fig. 4, *co*). The body-cavity thus shows from above downwards the comparatively small intestine, now rounded, and the massive glandular wall of the stomach in the middle, both being surrounded by a firm investment which leaves what may be called the keel of the stomach to be attached to a pointed incurvation of the ventral wall. On each side of the latter is the thick central mass of the longitudinal muscles, which externally also present another increase before being lost on the body-wall. A considerable perivisceral cavity exists on each side of the digestive organs.

Behind the foregoing the body-wall becomes thicker and the central chamber less, especially as the stomach ends in the intestine. The ventral muscles have considerably increased in bulk, and the double inflection for the longitudinal muscles on each side of the median line more marked. At the curvature of the alimentary system in the body-cavity, the pedicle proper commences, the external wall having a proportionally thicker coating of hypoderm than the body-proper, and supported internally by the basement-layer, which forms the W-shaped pattern inferiorly with a secondary curve on each outer leg. The ventral half of the space is filled with the muscular fibres, while the rest is split into two divisions by the median septum continued from the alimentary canal. The sides of the septum and the inner surface of the wall are covered with fibres. The buccal shield extends backwards to this region in the form of a broad, thin lamella, having a median line of basement-tissue separating the ventral and dorsal layers of hypoderm, and so little has the pedicle increased in length, that in some cases the free posterior

margin of the disk almost touches the pedicle of the parent to which the bud is attached. The pigment in the disk now approaches the condition in the adult.

The body-cavity of the buds at this stage thus glides insensibly into the first part of the pedicle, but the brevity of the latter organ gives rise to rapid changes in section. The next slice, indeed, shows the muscular fibres filling up the entire central area of the pedicle, while the septum proceeds only a short distance inwards from the dorsal wall. A somewhat radiate arrangement of the fibres also takes place, and is best marked ventrally in transverse section. After a short course the fibres terminate on the hypodermic covering of the end of the pedicle, which at this stage presents proportionally great development. The immature pedicle of the bud thus differs from that of the adult in the outline of the basement-layer, which is simply reniform in transverse section, whereas that of the adult presents two mamillæ on each side ventrally, and a median dorsal fold.

Externally, as indicated, the short pedicle almost immediately follows the anterior dorsal projection of the body; and as a peculiar curvature of the latter has now taken place, the tip of the pedicle scarcely projects beyond the margin of the disk. Shortly after reaching the stage just described, and while the symmetrical series of filaments on each side of the plumes is quite small, the bud separates from the parent. The pedicle and its sucker-like hypodermic termination are fairly developed; and as soon as it is detached (and sometimes before) a little bud appears near the tip. Thus the increase of the species by budding alone must be considerable, even comparatively young forms giving rise to a succession of buds. One or two buds are most frequently seen on the pedicle of the adult, though occasionally three or more exist.

Shortly before obtaining freedom the buds in some cases present a striking resemblance to certain stages in the buds of *Rhabdopleura*, as shown by Professor Allman. Thus in examples in which the first pair of plumes are very long and the succeeding short, while the stalk is in a state of extension, a condition closely approaching Professor Allman's figure 8 [1] is produced.

The buds thus differ from those in *Rhabdopleura* in attaining freedom on reaching a certain stage, but both probably arise in a similar way, two at least of the embryonic layers taking part in their production. The first layer is represented by the dermal layers, nervous centre, buccal region, and the rectum, and the second by the skeletogenous tissue and longitudinal muscles. The presence of the third layer, as already mentioned, is more doubtful, though it is possible that the cells and globules observed towards the end of the pedicle may be of hypoblastic origin, being derived from the central region of the alimentary canal. The sections of the younger buds present, in the arrangement of the alimentary canal, a close resemblance to the young *Pedicellina*, as shown by the careful researches of Dr. Barrois and Mr. Harmer. The position of the

[1] *Quart. Journ. Micr. Sci.*, 1869, vol. ix., pl. viii.

ganglion in the diagram[1] of the latter would nearly correspond with the nerve-centre in *Cephalodiscus*.

In *Loxosoma* the position of the buds is very different, viz., in the region of the stomach, and there are also often more than two.

Homologies.

Cephalodiscus approaches *Rhabdopleura* very nearly in many structural features, and it is probable, when more complete investigation of both is carried out, these resemblances will be increased rather than diminished.

Thus the *Cœnœcium* in both is largely developed and wholly independent of the polypides, while it is mainly secreted by the buccal shield or disk. The regularly ringed cylindrical cœnœcium of *Rhabdopleura* is, however, very different in form from the irregular, much branched and hispid cœnœcium of *Cephalodiscus*. Moreover, in the latter it is the secretion of the adults, whereas in *Rhabdopleura* much of it would appear to be the product of the younger buds. *Phoronis*, again, secretes its simple gelatinous investment in the sand, or in the form of tubes attached to stones or other foreign bodies, while an Australian species betakes itself to the gelatinous case of *Cerianthus*.[2] There is thus comparatively little method in the formation of its isolated dwelling. *Balanoglossus*, on the other hand, has only a mucous lining to its perforation in the sand, though the secretion of this form is also very abundant. Further, Bateson describes a peculiar odour in the living animals, and the spirit-preparations of *Cephalodiscus* also give evidence of a characteristic odour, though it may differ from that of the former.

The general form of the polypides of *Cephalodiscus* and *Rhabdopleura* diverges very considerably, the former being free, while the latter is fixed by the axial stem. Both, however, are small, while the size attained by *Phoronis* is a distinctive feature, as also is the absence of a pedicle from its cylindrical body.

The *Buccal Shield* is much larger in *Cephalodiscus* than in *Rhabdopleura*, and its secreting powers more active. The buccal shield is absent in *Phoronis* as such, but is represented by the epistome. As will be pointed out by Mr. Harmer, the proboscis of *Balanoglossus* appears to be the homologue of the disk, though only one proboscis-pore is usually present, while two exist in *Cephalodiscus*. Further examination is necessary in regard to these organs in *Rhabdopleura*.

The *Branchial Plumes* have a kind of skeletal system or basement-tissue in both *Cephalodiscus* and *Rhabdopleura*, but they are much fewer in the latter than in the former, which, moreover, has a bulbous and glandular tip to the main axis, thus simulating such organs as the large eye at the tip of the branchiæ of *Branchiomma*. The large

[1] *Quart. Journ. Micr. Sci.*, October 1886, vol. xxvii., pl. xxii. fig. 19.
[2] *Vide* Dr. Haswell, *Proc. Linn. Soc. N. S. W.*, vol. vii. p. 607.

size and firm nature of the simple branchial filaments of *Phoronis* are sufficiently diagnostic, as also is the fine, double, convoluted arrangement seen in the Philippine and Australian forms. The skeleton and circulatory system of these organs is much more highly developed than in either *Cephalodiscus* or *Rhabdopleura*. In *Balanoglossus*, again, considerable divergence has happened, for the branchiæ are now arranged in lateral series along the second region of the body, and are supported by an elaborate skeleton of chitinous elements[1] and furnished with numerous gill-slits. Such a modification, however, does not seem very far fetched when a section of the bases of the filaments after entering the axis of the plumes is made in *Cephalodiscus*. In connection with the arrangement of the plumes it is also interesting that in the Eupolyzoa (*e.g.*, as described by Allman[2] in *Paludicella*, Nitsche[3] in *Flustra membranacea*, and Haddon[4] in *Flustra carbasea*) the growing tentacles in the bud present bilateral symmetry.

The *Circulatory System* is evidenced only by the lacunæ (nuchal or collar-spaces) and their connections with the bases of the plumes in *Cephalodiscus*, but it would appear to be more largely developed than in *Rhabdopleura*, for its presence has not yet been indicated in that form. The circulatory system in *Phoronis* attains a much higher degree of complexity, since its large vascular ramifications with the well-marked nucleated corpuscles have no parallel in either. *Cephalodiscus*, however, agrees in that its collar-spaces are in connection with the reticulated or lattice-like centre of the main stem in each plume. The circulatory system in *Balanoglossus*, again, is also largely developed, especially in connection with its branchial system, though the contents of the vessels are less conspicuous. On this head all the foregoing widely diverge from the ordinary Polyzoa.

The *Digestive Apparatus* in both *Cephalodiscus* and *Rhabdopleura* closely agrees with the type in the Polyzoa, all being characterised by the flexure which causes the close proximity of mouth and anus. Moreover, the pyloric differentiation indicated in *Cephalodiscus* is prevalent in the Polyzoa and also in *Phoronis*, and though it has not been described in *Rhabdopleura*, traces of it may yet be found. The environment of the mouth in the latter and *Cephalodiscus* is related, but while the post-oral lamella is connected with the buccal shield in *Rhabdopleura*, it forms a special structure in *Cephalodiscus*. In *Phoronis* the general plan of the digestive system is the same, though the pyloric region of the stomach attains much greater size. In regard to this system all the foregoing closely approach the Eupolyzoa, the œsophagus, stomach, pyloric vestibule, intestine and rectum showing a similar arrangement. When *Balanoglossus*,

[1] *Vide* Monograph on the Brit. Nemerteans, Ray Society, 1872–73, p. 146.
[2] Fresh-water Polyzoa, p. 36.
[3] *Zeitschr. f. wiss. Zool.*, 1871, Bd. xxi. p. 457.
[4] *Quart. Journ. Micr. Sci.*, 1883, vol. xxiii. p. 518.

however, is contrasted with them very considerable differences are encountered, one of the most decided being the straightness of the canal and its terminal anus.

The *Nervous System* is præ-oral in *Cephalodiscus* and it has a somewhat peculiar structure. It is situated between the hypoderm externally and the basement-tissue internally. None has yet been described in *Rhabdopleura*, and thus comparison at present must remain in abeyance. In *Phoronis* the nervous elements, which lie along the base of the branchial processes, are similar to those in *Cephalodiscus*, and there is also a central area between mouth and anus. The nervous system is subhypodermic, and is chiefly concentrated in the corresponding region to that in *Cephalodiscus*. So far as known, therefore, all have something in common under this head.

Unless the oviducts in *Cephalodiscus* are to be credited with remarkable functions, sense-organs, so far as can be noticed in the spirit-preparations, are absent. Further inquiry is necessary on this head, but I am inclined to consider with Dr. Marcus Gunn, on whose special experience and caution I place reliance, that there is no refractive mechanism. This localized pigment perhaps indicates either phosphorescent organs or local heat-producers. In *Rhabdopleura* a pair of ciliated pads or papillæ occur at the bases of the plumes, the minute structure of which, however, is in need of careful revision. *Phoronis*, again, presents only the ciliated furrows, which are external to the anus, and have a nervous expansion beneath the hypoderm. In *Loxosoma* papillæ similar to those just described occur on the dorsal aspect, and the subœsophageal ganglion is well developed, as shown in Harmer's beautiful researches on *Loxosoma crassicauda*.

The structure of the *Body-wall* in *Cephalodiscus* considerably diverges from that in *Rhabdopleura*, the definite layers of hypoderm and basement-tissue in this form contrasting with the cuticular epithelium and underlying connective-tissue cells in the latter. Something like basement-tissue seems to be indicated in Lankester's pl. xl. fig. 12 (though no mention of it is made), and he describes and figures the enteric epithelium lining the body-cavity, the cells being connected with the wall of the stomach by processes. The body-wall in *Phoronis* again deviates from that in either of the foregoing, since, besides cuticle, hypoderm and basement-tissue, it shows a circular and a longitudinal muscular coat, the latter being chiefly grouped in longitudinal bands which in transverse section show a somewhat pennate arrangement. There is little in common, therefore, beneath the basement-tissue, and the absence of the pedicle in *Phoronis* is a marked feature of divergence. The structure of the body-wall of *Cephalodiscus* most nearly approaches that of *Balanoglossus* (a phosphorescent form), though there is a wide gap in this respect as there also is between it and *Phoronis*. In *Loxosoma* a transparent cuticle and a hypodermic layer, "associated at certain points with muscular fibres more or less pronounced," according to Vogt are present.

Cephalodiscus and *Rhabdopleura* agree in certain respects in regard to the *Body-cavity*, but the former has the pedicle as an appendix. *Phoronis* on the other hand has

a much more spacious chamber divided by various mesenteries. In *Balanoglossus* this chamber posteriorly is inconspicuous in the adult. The condition again in the Entoproctous Polyzoa (*e.g.*, *Loxosoma*) considerably diverges, for no body-cavity exists; while in the Phylactolæmata it is present in the adult, and is lined by ciliated epithelium, such not being the case in the body-cavity of the Gymnolæmata.

It is an interesting fact that the *Muscular System* both in *Cephalodiscus* and *Rhabdopleura* is connected with the pedicle, if we may for the moment so term the soft contractile stalk of the latter. In the former, however, it is much more largely developed and is continued directly from the body-cavity; whereas in *Rhabdopleura* it is wholly external to that chamber, and is less distinctly differentiated on the surface of the axial skeleton, which forms another feature of distinction in this form. If the funiculus of one of the Eupolyzoa be disconnected from the digestive system and formed into an external process in the line of the ordinary communication-plate, something similar in structure and function to the pedicle in the Aspidophora will be made. As a rule in the same group the retractor muscles of the body and lophophore arise from the peritoneal lining.

The funiculus of the Eupolyzoa, according to Haddon, is probably derived from the irregular strands of funicular tissue which occur in the parent zoœcium. It appears as a thickish cord stretching from the fundus of the developing polypide to the base of the zoœcium. It is in direct communication with the brown body, directing "the developing alimentary tract to that nutritive mass, thereby ensuring the better nutrition of the growing bud." The bud is thus developed at a distance from the brown body, but approaches it and extracts nutriment from it. This has been noted by other authors. In *Loxosoma* the stem quite differs, since there is no communication with the body-cavity.

The present condition of our knowledge of the *Reproductive Organs*, both in *Cephalodiscus* and *Rhabdopleura*, is incomplete, so that a satisfactory comparison cannot be made. The ova in the former are very large, but no male elements have been seen. In *Rhabdopleura* the testis occurs as a long sac adjoining the intestine and even projecting beyond the abdomen. It opens near the anus, and thus agrees with the condition in *Cephalodiscus* and *Phoronis*, as well as offers certain resemblances to the condition in the Entoproctous Polyzoa. The reproductive organs in *Phoronis* are posterior in position, and both male and female elements are usually conspicuous. In *Balanoglossus* these elements occur between the liver and the anterior part of the body.

The early appearance of the ova in the young buds of the Eupolyzoa, for instance *Bugula flabellata*, as noticed by Haddon, is worthy of mention. These ova are in close relation to the wall of the digestive tract. The distinction of the Aspidophora from those of the Eupolyzoa in which the ova of the parent pass ready-formed into buds is marked.

Budding.—The fact that *Cephalodiscus* is free while *Rhabdopleura* is fixed causes considerable divergence in regard to the buds; and, moreover, the functions performed by the bud in the latter species, while yet incompletely developed, and with a bifid buccal shield (viz., the secretion of the cœnœcium or tubarium) is an important difference. Another essential divergence is the occurrence of the buds in a regular series on *Rhabdopleura*, the youngest nearest the terminal polypide, the oldest next the distal. The confinement of the buds in *Cephalodiscus* to the region just within the terminal hypodermic plate is peculiar, and makes it difficult to institute anything like parallelism between them in this respect. Further, Lankester is inclined to think that after the complete development of the polypide in *Rhabdopleura*, there is no evidence that it takes upon itself bud-production; that is to say, the buds are given off at an early period of its growth. It is not quite clear, however, that the budding of this form is in the same category as that of *Cephalodiscus*, in which the stalk is a process of the body-cavity, whereas the soft stalk of *Rhabdopleura*, if the descriptions are understood correctly, has not yet been shown to be so, though at first sight it might be interpreted otherwise. Nothing like the arrested buds of this form is known in *Cephalodiscus*. The source of the hypoblastic elements, if these are present, in the bud of *Rhabdopleura* is thus in obscurity. In *Phoronis* no bud is known, while the small ova are extremely numerous, and the embryos (having the form of the well known Actinotrocha) pelagic. In *Balanoglossus* likewise no bud occurs, the ova are numerous and small, and the embryo free-swimming (Tornaria).

On taking a general survey of the subject, then, it occurs to me that in the present state of our knowledge, and while fully admitting the remarkable resemblances between it and certain hitherto isolated types such as *Balanoglossus* (which I have for the most part left in the able hands of Mr. Harmer), it will lead to no disadvantage if *Cephalodiscus* be left as formerly near the Polyzoa; and, further, though the divergences between it and *Rhabdopleura* are noteworthy, in the same group as formerly, viz., the Aspidophora of Professor Allman. It is well to exhaust the structural, developmental, and other features in the various forms reviewed in the preceding paragraphs before changes in classification are promulgated.

Cephalodiscus approaches the Polyzoa in regard to its cœnœcium, its digestive system, and its buds, and it is peculiar that in these points there is a lack of conformity in *Balanoglossus*, and to some extent in *Phoronis*. Viewed as a whole, the several systems mentioned agree most with the type of the Polyzoa. Though *Phoronis* forms a tube, and *Balanoglossus* secretes very abundant mucus, a feature common to many diverse groups, such as the Nemerteans, Discophora, and Mollusca, nothing like the regular cœnœcium of *Rhabdopleura* or *Cephalodiscus* is constructed. While again the digestive system of *Phoronis* resembles that in the Polyzoa, the same system in *Balanoglossus* is very different, for the straight alimentary canal with its terminal anus has no

parallel in the life-history of *Cephalodiscus*, not even an embryonic approach occurring in either form. The anus in *Balanoglossus* is posterior and terminal at all stages. The relations of the dorsal and ventral surfaces in the two forms are also at variance. Buds again, are unknown in either *Phoronis* or *Balanoglossus*, and in both the eggs are very numerous and small, whereas in *Cephalodiscus* they are few and very large.

The main resemblances between *Cephalodiscus* and *Balanoglossus* lie in the structure of the skin, the presence of three body-cavities (disk, collar, and body proper), the proboscis or disk-pores, collar-pores, gill-slits, and rudimentary notochordal structure, and they are of a most interesting and suggestive character; and as Mr. Harmer, whose valuable researches on the Entoproctous Polyzoa are well known, has most ably studied these features and formed independent conclusions, I have thought it best to give his views in his own words as an Appendix. These will show how difficult it is in some cases to draw clear lines of distinction—so intimately are the several characters, in apparently diverse groups, blended. In a former paper[1] I had observed with regard to *Phoronis* and *Balanoglossus*—"If indeed the branchial skeleton supporting the vessels (of *Phoronis*) were thrown in, and arranged at the sides of the anterior region of the body, so that the water would enter by lateral slits to aerate the circulating fluid, and the digestive canal enlarged and attached as a single tube to the body-wall, a form resembling *Balanoglossus* would be indicated." It has to be borne in mind also that Alexander Agassiz thought that the latter resembled the Tunicates from the nature of the gills and their mode of formation, in opposition to the views of Kowalevsky and others, who placed its affinities with the Annelids proper.

Perhaps *Balanoglossus* may at present be ranged near the Aspidophorous group of the Polyzoa, for though Metschnikoff's view that it approaches the Echinoderms rests on the remarkable fact that in Tornaria the original evagination from the gut is on the left side, just as in Asteroid larvæ the water-vessel is developed from the left primitive diverticulum (Bateson), yet there are stronger reasons for associating it with other groups as above mentioned.

[1] *Proc. Roy. Soc. Edin.*, Session 1880–81, vol. xi. p. 217.

APPENDIX.

By Sidney F. Harmer, B.A., B.Sc., Fellow of King's College, Cambridge, and of University College, London.

The following observations on *Cephalodiscus* were made in consequence of a letter received from Professor M'Intosh, calling my attention to certain remarkable features in the anatomy of the genus. I am very greatly indebted to Professor M'Intosh for his courtesy in giving me specimens of *Cephalodiscus*, and most of all for his kindly expressed desire that I should publish my conclusions as an appendix to his own monograph. Time has not permitted of my seeing the proofs of this monograph, and I must therefore claim indulgence for any descriptions which would otherwise appear unnecessary repetitions of the results of Professor M'Intosh himself.

In examining sections of *Cephalodiscus*, I have been struck with the existence of various organs which appear to me to point to the conclusion that this remarkable genus is a near ally of *Balanoglossus*. This very unexpected result will be understood by comparing the following woodcuts (with the remarks which accompany them) with Bateson's papers on the anatomy and development of *Balanoglossus*.[1]

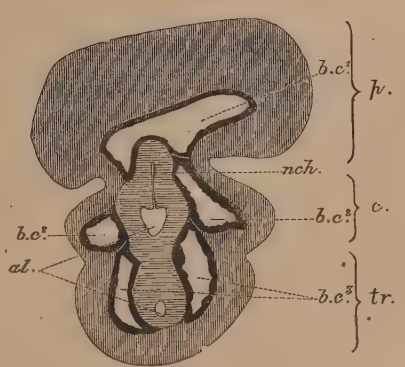

Fig. 1.

Fig. 1.—*p.*, proboscis; *c.*, collar; *tr.*, trunk; *al.*, alimentary canal; *nch.*, notochord; *b.c.*¹, body-cavity of proboscis; *b.c.*², body-cavity of collar; *b.c.*³, body-cavity of trunk.

Fig. 1 represents a longitudinal, right and left, section of a young bud of *Cephalodiscus*. The resemblance between this section and Bateson's diagrams of the larvæ of *Balanoglossus*[2] is, in all essential details, exact. The body of the young *Cephalodiscus* is divided, by means of two transverse grooves, into three well-marked regions. Of these the anterior (*p.*) may be compared to the proboscis of *Balanoglossus*; the middle division (*c.*) to the collar of the same animal, and the posterior division (*tr.*) to the trunk or body. It will further be noted that the proboscis is pro-

[1] *Quart. Journ. Micr. Sci.*, vols. xxiv., xxv., xxvi.

[2] *Quart. Journ. Micr. Sci.*, vol. xxvi., pl. xxxiii. fig. 7.

vided with an anterior, undivided body-cavity, the collar and the trunk each containing a body-cavity which is composed of two halves separated by means of dorsal and ventral mesenteries. These five spaces are completely separated from one another, and their arrangement is in exact accordance with that of the corresponding sections of the

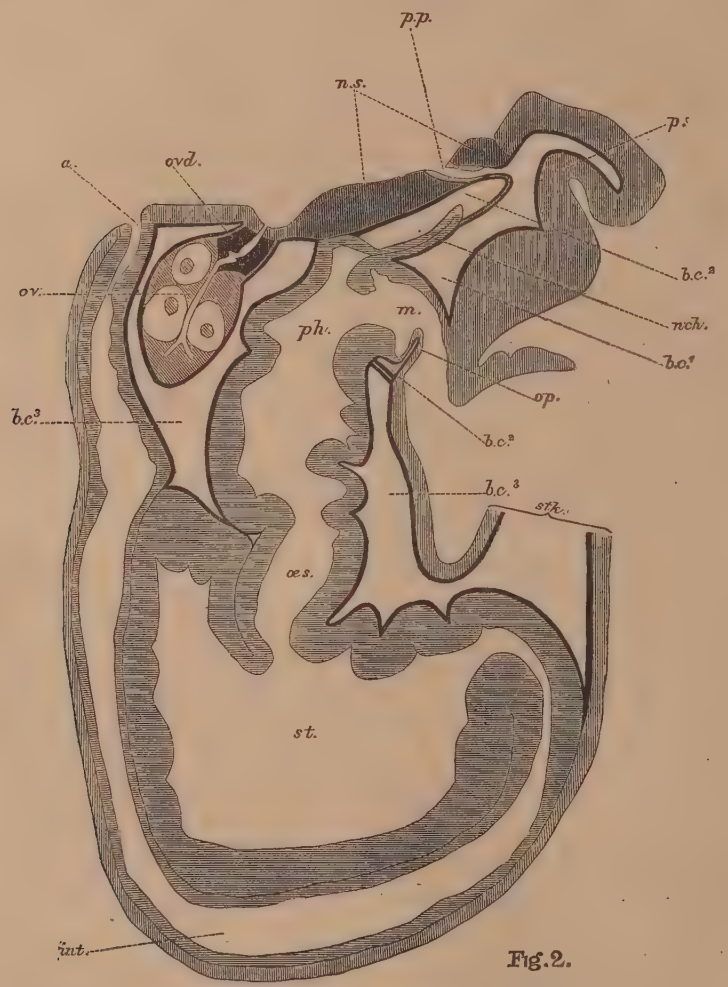

Fig. 2.

Fig. 2.—Longitudinal section of an adult *Cephalodiscus*, supposed to be taken sufficiently on one side of the middle line to allow of the representation of one of the ovaries, and of one of the proboscis-pores. *p.*, proboscis; *stk.*, stalk; *m.*, mouth; *ph.*, pharynx or branchial region of gut; *œs.*, œsophagus; *st.*, stomach; *int.*, intestine; *a.*, anus; *nch.*, notochord (really visible only in a median section); *ov.*, ovary; *ovd.*, pigmented oviduct; *b.c.*¹, *b.c.*², *b.c.*³, divisions of body-cavity as in fig. 1; *p.p.*, one of the proboscis-pores; *op.*, operculum; *n.s.*, central nervous system.

body-cavity in *Balanoglossus*. The similarity of *Cephalodiscus* to the same animal is rendered still more striking by the existence in the former of a diverticulum (*nch.*) of the front part of the alimentary canal, extending a short distance forwards into the region of the proboscis, and homologous with the notochord described by Bateson.

The course of the alimentary canal is sufficiently explained by means of fig. 2.[1] The mouth (*m.*) is seen to be overhung by the large proboscis (*p.*), otherwise known as the epistome or buccal shield. The dorsal and ventral mesenteries are not visible, since the section is not exactly median. The third body-cavity (*b.c.*^{3}) is very large, and contains the alimentary canal and ovaries. The anterior body-cavity (*b.c.*^{1}) continues to form the lumen of the proboscis, whilst the relations of the collar-cavities are not quite those of the preceding figure. Dorsally the two halves of the body-cavity of the collar have extended forwards into the proboscis region, whilst ventrally they are to be found (apparently fused ?) solely in the post-oral lamella or operculum. The cavities of the proboscis and of the collar (and more particularly of the latter) are to some extent obliterated by muscles and connective-tissue. The notochord (*nch.*) has, in the adult, the form of a slender bar, provided with a fine lumen, stretching forwards in the proboscis-stalk into the proboscis itself. It is continuous at its base, as in the young bud, with the epithelium of the alimentary canal.

The further relations of the notochord will be described in connection with fig. 4.

The central nervous system is developed on the dorsal side of the collar as a mass of ganglion-cells and nerve-fibres lying outside the basement-membrane of the epidermis. It is, however, continuous anteriorly with a similar development of nervous tissue situated on the dorsal aspect of the proboscis, and laterally with a well-developed nerve-layer on the dorsal sides of the lophophoral arms. In the young bud, in which the collar is represented by a region of the body separated by transverse grooves from the proboscis on the one hand and the trunk on the other, the condition of the central nervous system as a development of the collar is particularly well marked, although even at an early stage a thinner nerve-layer occurs on the proboscis. In the adult there is no sharp line between the nervous tissue of the collar and that of the proboscis. At about the level of the anterior end of the notochord, the nerve-layer is perforated by a pair of pores—apparently derivatives of the ectoderm, which pass from the exterior into the body-cavity of the proboscis (*p.p.*, fig. 2). These pores are disposed symmetrically with regard to the median plane of the animal, and are at no great distance from that plane.

In most species of *Balanoglossus*, it is well known that an asymmetrical proboscis-pore occurs on the left side, whilst in *Balanoglossus kupfferi*[2] two proboscis-pores are present. It is thus obvious that the proboscis-pores of *Cephalodiscus* are a further feature in support of the view that this animal is related to *Balanoglossus*, the disposition of these pores in *Balanoglossus kupfferi* being in this respect particularly noteworthy.

One of the two ovaries (*ov.*) is represented in section in fig. 2. The duct (*ovd.*) is

[1] A fold in the intestinal region of the alimentary canal, of the existence of which I have been informed by Professor M'Intosh, has not been inserted in the diagram.

[2] *Vide* Bateson, *Quart. Journ. Micr. Sci.*, vol. xxvi. p. 555.

of a rich brown colour owing to the existence of pigment in its walls; the oviducts have on previous occasions been described as eyes.

Fig. 3 will serve to illustrate the anatomy of the collar-region of *Cephalodiscus*. Whilst in the bud, this region is distinctly marked out by transverse grooves passing round the body of the animal, this distinctness is no longer visible externally in the adult form. The collar-region is, notwithstanding, no less sharply marked out internally than at younger stages. Its body-cavity (*b.c.*^{2}) is perfectly distinct from the remaining cœlomic spaces of the animal, although it is to a considerable extent (and especially in the lophophoral arms and the operculum) filled by loose connective-tissue (as in *Balanoglossus*). The dorsal part of the collar is produced on each side into six tentacular arms, into which (and into the individual tentacles) the collar-cavity may with ease be traced. The nervous system (*n.s.*) extends on to the dorsal face of each arm. The ventral border of the collar is produced into a free fold, the operculum or oral lamella, which reaches its highest development laterally and ventrally (with the exception of the median line in the latter region). It has before been stated that the collar-cavities extend, dorsally, for some distance along the proboscis region (*vide* fig. 2, *b.c.*^{2}), and as a matter of fact, the anterior limit of these cavities is coincident with the origin of the most anteriorly placed lophophoral arms. The collar is much less developed on the ventral side (*b.c.*^{2}, fig. 2); its cavity in this region being, however, continuous at the sides of the alimentary canal with the dorsal part. The posterior border of the collar passes on each side of the body along a line, which would be roughly indicated in fig. 2 by joining the posterior end of the nervous system, dorsally, to the base of the operculum, ventrally. This line corresponds, on each side of the body, with the origin of the oral lamella or operculum. Since fig. 3 represents a section taken near

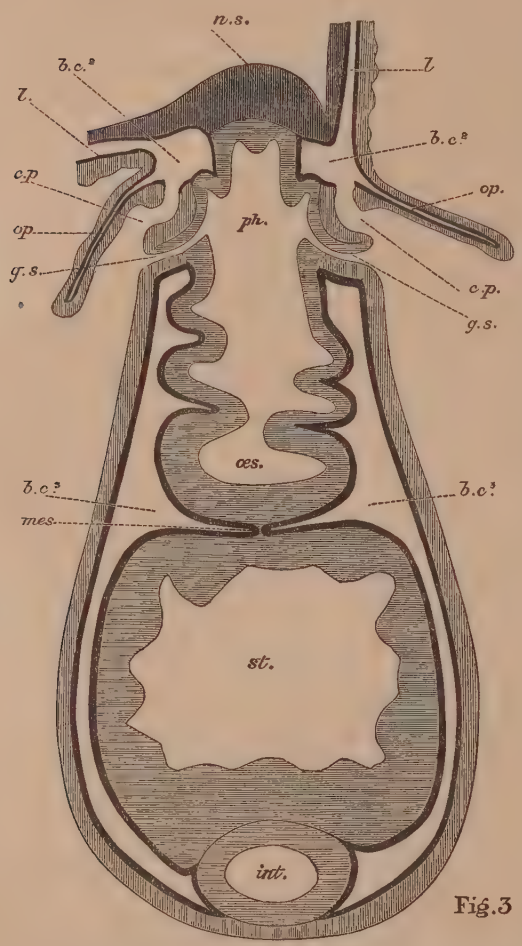

Fig. 3

Fig. 3.—Longitudinal right and left section through an adult *Cephalodiscus*, passing through the pharnyx (*ph.*), œsophagus (*œs.*), stomach (*st.*), and intestine (*int.*); *n.s.*, nervous system; *l.*, lophophoral arms; *op.*, operculum; *c.p.*, collar-pores; *gs.*, gill-slits; *mes.*, dorsal mesentery; *b.c.*^{2}, body-cavity of collar; *b.c.*^{3}, body-cavity of trunk.

the posterior limit of the central nervous system, it is intelligible (from the relations of the base of the operculum just explained) that the operculum is seen, in the section, to spring from a region of the body quite near to the dorsal surface. It is, however, clear that the operculum is merely a free fold of the posterior border of the collar-region, containing a portion of the collar-cavity, and that it is therefore exactly comparable to the operculum described by Bateson in *Balanoglossus*.

On each side of the body is found a well-marked "collar-pore" (fig. 3, *c.p.*), consisting of a very short canal whose walls are formed of narrow, closely arranged epithelial cells, and opening on the one hand into the cavity of the collar, and on the other to the exterior, the external openings of the pore being overhung by the base of the opercular fold. Both in the structure and in the position of these canals, *Cephalodiscus* resembles *Balanoglossus* to an extent which is almost inconceivable, except on the hypothesis of some genetic connection between the two genera.

A further *Balanoglossus*-feature possessed by *Cephalodiscus* is the existence of a pair of well-marked gill-slits (fig. 3, *g.s.*) opening to the exterior immediately behind the collar-pores, and so far as I have been able to make out from an examination of the buds, apparently developed as outgrowths of the "pharyngeal" region of the alimentary tract. The relation of these slits to the collar-pores is precisely the same as that of the first pair of gill-slits of *Balanoglossus* to the collar-pores of the latter. Unlike *Balanoglossus*, *Cephalodiscus* possesses no more than a single pair of gill-slits, but it must be remembered that the young *Balanoglossus* remains for some time in a similar condition (*i.e.*, with but a single pair of gill-slits), and that Bateson has assumed the existence of an ancestor of *Balanoglossus* in which no metameric repetition of the gill-slits had taken place.

Fig. 4 illustrates the relation of the structures in the proboscis-stalk, which—as in *Balanoglossus*—is a constricted region by which the proboscis itself is connected with the rest of the body. The completely separated collar-cavities are clearly visible, as well as the unpaired proboscis-cavity. The notochord is a slender rod, possessing a fine lumen, and is supported by the mesentery, which forms the division between the two halves of the collar-cavity. I am not at present certain as to the existence or non-existence of Bateson's "proboscis-gland" in this region of the body.

The lophophoral arms are deeply grooved on their ventral surfaces, and these grooves are continuous with shallower furrows (*gr.*), which pass along the ventro-lateral portions of the collar, on either side of the proboscis-stalk, as far as the region of the mouth. If, as can hardly be doubted, the tentacles are ciliated, it may be assumed that a current of water passes in the living animal down these grooves into the mouth, into which the current is directed by means of the opercular flap developed from the posterior border of the collar. It is probable that the gill-slits are, in this case, of great importance to the animal. The two lateral currents which have just been supposed to enter the mouth would doubtless introduce large quantities of water into the pharynx. The water would

pass to the gill-slits by a very slight alteration of the direction of these currents, since the gill-slits open ventro-laterally from the first division of the alimentary canal. Solid particles conveyed by the current could presumably be readily retained in the alimentary canal, whilst the water itself would naturally pour out by the gill-slits, which would be protected from the afferent current due to the tentacles by means of the operculum. It thus seems possible to conceive of a method in which the gill-slits may be of the greatest importance in connection with the straining of the water from the food-particles. Bateson has been led to assume that gill-slits are structures which have been developed within the Chordata, and it is suggestive that in *Cephalodiscus*, owing to the rich development of the tentacles, we appear to have a cause capable of inducing the evolution of perfora-

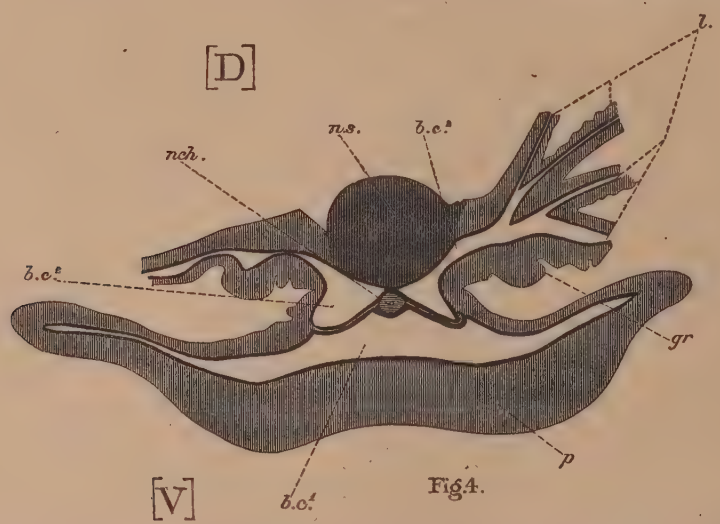

Fig. 4.

Fig. 4.—Transverse section through the collar and proboscis of an adult *Cephalodiscus*, passing in front of the mouth: *n.s.*, nervous system; *p.*, proboscis; *l.*, two of the lophophoral arms cut horizontally; *gr.*, grooves continuous with the grooves of the anterior lophophoral arms; *b.c.*^{1}, body-cavity of proboscis; *b.c.*^{2}, body-cavity of collar; *nch.*, notochord; D., dorsal, and V., ventral surface.

tions leading from the alimentary canal to the exterior. It may be perhaps profitable to consider whether gill-slits may not possibly have originated in this manner, and whether the arrangement found in *Balanoglossus* and other types may not have been developed from a *Cephalodiscus*-like condition by the metameric repetition of the slits, accompanied by a change in their function.

The preceding remarks relating to the supposed affinity of *Cephalodiscus* to *Balanoglossus* may with advantage be summed up by a statement of the various features which are common to the two genera.

1. Division of the body into proboscis, collar and trunk, this division being specially obvious, in *Cephalodiscus*, in the young bud.

2. Existence of an unpaired body-cavity in the proboscis, and of paired cavities in the collar and in the trunk.
3. Proboscis-pores (paired in *Balanoglossus kupfferi*), opening into the body-cavity of the præ-oral lobe.
4. Collar-pores in similar relation to the collar-cavity, their external apertures being overhung by an operculum developed from the collar.
5. Gill-slits (one pair for a considerable period in the embryonic history of *Balanoglossus*); their relation (in *Balanoglossus*, the relation of the first pair) to the operculum and to the external apertures of the collar-pores.
6. Existence of a notochord as a diverticulum of the alimentary canal, growing forwards into the proboscis-stalk.
7. Dorsal central nervous system, most richly developed in the collar, but extending on to the proboscis; the fact that the nervous tissue lies in the epidermis.

Before leaving this subject, it will be well to refer briefly to the highly interesting pelagic larva of *Balanoglossus*, discovered by Weldon in the Bahamas.[1] A noteworthy feature of this larva is the development of a series of tentacles arranged in six grooves passing, equidistant from one another, in a longitudinal direction along the surface of the præ-oral lobe. Although the tentacles are not in the same position as those of *Cephalodiscus*, it is a suggestive fact that this larva affords another case of the development of tentacles in the anterior part of the body in *Balanoglossus* or its allies, and it is at least possible that their appearance in the Tornaria may be due to a process of reversion or atavism.

It appears to me that whatever may be thought of any single similarity between the two genera given in the above list, the cumulative evidence of the whole sequence of resemblances points irresistibly to the conclusion that *Cephalodiscus* and *Balanoglossus* are near allies, and I would propose to remove *Cephalodiscus* from its previous position amongst the Polyzoa, and to place it definitely as a second genus in Bateson's group of the Hemichordata. The character of the Vertebrate features of *Cephalodiscus* (notochord, gill-slits, nervous system) appears to justify an approximation of this genus to *Balanoglossus* in particular rather than to any other group of the Chordata.

The most important difference between *Cephalodiscus* and *Balanoglossus* appears to me to consist in the relations of the dorsal and ventral surfaces in the two genera. The difference is, however, a non-essential one. Whilst in *Balanoglossus* the elongation of the embryo takes place in the line of its long axis, the ventral elongation of a similar embryo in a line at right angles to its primitive long axis would give rise to the condition found in *Cephalodiscus*. We may suppose that the stalk has originated in this

[1] *Vide Proc. Roy. Soc.*, vol. xlii. p. 146, 1887.

manner, and that the alimentary canal has acquired its adult relations by its partial passage into the ventral protuberance of the body.

Whilst it appears to me easy to compare *Cephalodiscus* and *Balanoglossus*, it does not seem to me impossible that the former may have affinities in other directions as well. For, imagine that the ventral elongation of the body would be conveniently postponed until after the end of a free larval life; the stalk might then be invaginated into the body of the larva in preparation for its evagination when metamorphosis should take place, as actually occurs in Actinotrocha. After the metamorphosis of the latter, the alimentary canal has the same dorsal flexure as in *Cephalodiscus*, and this explanation of the metamorphosis of *Phoronis* is in accordance with the suggestions of previous observers.

The following considerations may perhaps indicate some affinity between *Cephalodiscus* and *Phoronis*[1]:—

1. The archenteron of *Phoronis* is developed by a well-marked invagination, whilst part of the mesoblast (*vide* Caldwell) is formed by a process of (modified) archenteric pouching (as in *Balanoglossus*).

2. The præ-oral lobe is large in Actinotrocha, and is provided with a body-cavity which is completely shut off, by means of a septum, from the body-cavity of the trunk. The post-oral region is prolonged into tentacles, which, although differing in a striking manner from the tentacles of *Cephalodiscus*, may still have some connection with these structures, or with the operculum of the same genus.

3. The "foot" of *Phoronis* has precisely the same relations as the stalk of *Cephalodiscus*.

4. The nervous system of *Phoronis* occurs outside the basement-membrane. The ganglion of the præ-oral lobe of Actinotrocha is comparable with a portion of the nervous system of the Hemichordata, whilst the post-oral nerve-ring of *Actinotrocha* (following the line of the bases of the tentacles) may not impossibly be the homologue of the nerve-ring which passes round the posterior border of the collar in *Balanoglossus*. If this were the case, the lophophores of Actinotrocha and of *Phoronis* might be regarded as developments of the collar-region.

5. *Phoronis* possesses a complete ventral mesentery, the dorsal mesentery, however (persistent in *Cephalodiscus*), having disappeared in the adult animal. The ovaries and oviducts of *Cephalodiscus* are supported by lateral mesenteries which are apparently arranged in the same manner as the lateral mesenteries in Caldwell's diagram "*B*."[2] The oviducts of *Cephalodiscus* do not, however, open into the body-cavity, and it is possible that the collar-pores, rather than the oviducts, may be the homologues of the nephridia of *Phoronis*.

[1] *Cf.* W. H. Caldwell, Prelim. Note on the Structure, Development, and Affinities of Phoronis, *Proc. Roy. Soc.*, No. 222, 1882; and Blastopore, Mesoderm, and Metameric Segmentation, *Quart. Journ. Micr. Sci.*, vol. xxv., 1885.

[2] *Proc. Roy. Soc.*, 1882.

6. Previous observers (M'Intosh, Lankester, &c.) have been led to assume the affinity of *Phoronis* to *Cephalodiscus* and *Rhabdopleura*, this conclusion being based on such features as the relations of the adult lophophore to the mouth and anus.

It must be noted, on the contrary, that *Phoronis* is not known to possess any representatives of the notochord, gill-slits, collar-pores, and proboscis-pores of *Cephalodiscus*, whilst there is no evidence of the existence of a collar body-cavity in the former. It appears to me that a renewed consideration of *Phoronis*, anatomically and developmentally, can alone settle the question of the possibility of an affinity between it and *Cephalodiscus*.

The remarkable larva of *Balanoglossus* described by Weldon (*loc. cit.*, fig. 3) is in some of its features by no means unlike Actinotrocha. Such features are the general form of the præ-oral lobe and trunk, the absence of the notochord and gill-slits, and the existence of only three divisions of the body-cavity. These are (1) the unpaired cavity of the præ-oral lobe, and (2) the two cavities of the trunk-region. In the absence of these cavities and of the notochord and gill-slits Actinotrocha differs from the larval *Balanoglossus* described by Bateson. It cannot, however, be denied that the difference between the tentacles of Weldon's larva and those of Actinotrocha is very considerable, if not fundamental.

The relation between *Cephalodiscus* and *Rhabdopleura* is in need of further elucidation. In spite of the great resemblance between the lophophores and epistomes of the two genera, many of the most important structures found in *Cephalodiscus* are not known to exist in *Rhabdopleura*, and there does not at present appear sufficient justification for the removal of *Rhabdopleura* to the Hemichordata, although the balance of evidence might perhaps be in favour of so doing.

I do not think that the above considerations are in any way calculated to strengthen the view that *Phoronis* and the Polyzoa are nearly related. The result of the examination of *Cephalodiscus* appears to me to show that this genus (and *Rhabdopleura* also?) must be entirely removed from the Polyzoa. If this is the case, it is obvious that any affinity which may be shown to exist between *Cephalodiscus* and *Phoronis* can in no way affect the question of the relationship of the latter to the Polyzoa.

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PLATE I.

PLATE I.

Cœnœcium of *Cephalodiscus dodecalophus*, about the natural size; a few of the branches terminate in somewhat flattened tips. At *a*, one of the pillars, which like aerial roots pass downwards to the stones and sponges on which it grows, is represented; its tip being expanded into a broad surface. Numerous inosculations take place between the various branches.

I have to thank Mr. E. E. Prince for most kindly aiding me in drawing certain figures, as indicated on the Plates.

F Huth, Lith^r Edin^r

CŒNŒCIUM OF CEPHALODISCUS DODECALOPHUS, M^c I.

(uncoloured)

PLATE II.

PLATE II.

Polypide of *Cephalodiscus dodecalophus*, seen from the ventral surface, and enlarged under a lens, the actual length of the entire animal being about 2 mm. Only a few of the tentacular plumes are visible, the rest being concealed by the dense mass of filaments. The tip of the pedicle bears an early bud, the pedicle of which is somewhat elongated. This example presented numerous minute pigment-spots of a brownish hue all over its surface.

V C M del.

F. Huth, Lith^r Edin^r

CEPHALODISCUS DODECALOPHUS, M^c I.

PLATE III.

PLATE III.

Fig. 1. Polypide of *Cephalodiscus dodecalophus*, obliquely seen from the ventral surface, much enlarged, and having the buccal shield removed. The pedicle is in a state of extension, with a fairly advanced bud at the tip; *an*, anus; *pl.*, post-oral lamella; *m*, mouth.

Fig. 2. Lateral view of a polypide, also deprived of the buccal shield, and much enlarged. The pedicle is contracted and bent forward, with a pair of buds at the tip. The same letters are used as in fig. 1; *ov*, the position of the large ovum, which distends the lateral region just behind the pigment-spots (*od*); *bp*, torn tissues at the base of the plumes, which have been removed.

Fig. 3. Lateral view of an entire specimen, with the pedicle as well as the buccal disk thrust outwards, or ventrally. The buccal shield has fallen from the larger of the two buds at the tip of the pedicle. The alimentary canal has been somewhat diagrammatically outlined in this example; *œ*, above the line is the pharynx, below is the œsophagus; *vt*, stomach, largely distended; *vtd*, peculiar region following the stomach, and presenting a thick glandular coat with a distinct fold beyond the point touched by the dotted line, and which probably is homologous with the second stomachal dilatation in *Phoronis*; *r*, rectum, usually much dilated; *bs*, buccal shield; *pl.*, post-oral lamella.

Fig. 4. An abnormal specimen, similarly magnified and viewed laterally. The pedicle is absent, a prominence only (*ped*) indicating its position. Instead of the smoothly bulbous posterior extremity (almost like the bowl of a retort), a somewhat sharp angle occurs ventrally. The anus is elevated on a rectal cone.

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CEPHALODISCUS DODECALOPHUS, M^c I.

PLATE IV.

PLATE IV.

Fig. 1. Tentacular plume of *Cephalodiscus*, seen as a semitranslucent object. The line in the middle of the filaments indicates the axis or skeleton; × 90.

Fig. 2. Portions of the pinnæ or filaments acted on by dilute potash so as to exhibit the central axis or skeleton, which at *a* has been exposed. The cellulo-granular coating of the organs is hypodermic; × 350.

Fig. 3. Slightly oblique section of the bulbous tip of one of the plumes, showing the large globules and gland-cells. The hypoderm has intruded on the left, showing that the slice has been made close to the base of the process; × 470.

Fig. 4. Transverse section of the tip of a plume just behind the foregoing, and while the central lumen remains very distinct. The hypoderm shows somewhat regular wedge-shaped divisions, as if composed of a single layer of large cells. The wall of the central cavity presents numerous fibres projecting all round, as if the reticulations were already commencing; × 470.

Fig. 5. Transverse section of the pedicle, showing the remarkable form usually assumed by the elastic basement-tissue (*bt*) in contraction. The hypoderm (*hp*) occurs externally; and within the basement-tissue the large muscular fibres and somewhat gelatinous connective-tissue fill up the central region. The small dorsal and the large ventral incurvations are readily recognised, as well as the two lateral ventral projections of the basement-tissue. The hypoderm on the ventral surface has been somewhat stretched; × 350.

CEPHALODISCUS DODECALOPHUS, Mc I.

PLATE V.

PLATE V.

Fig. 1. Tip of one of the plumes of the polypide of *Cephalodiscus*, showing the glandular nature of the enlarged region. The filaments (*f*) have been turned to the left; *ca*, central axis of main stem; *hp*, hypoderm. The longitudinal fibres running along the axis are observed to the left as well as over the axis; × 210.

Fig. 2. Portion of the middle of a plume with the bases of the filaments (*f*), viewed laterally, after the action of a dilute solution of potash. The skeletal axis is observed in the centre of each filament, and as this skeletal axis (*sk*) widens out at its base, the double outline at each side is well marked; *ca*, central axis of main stem, with its longitudinal fibres; × 350.

Fig. 3. Transverse section of a young bud on the appearance of the first two lophophoral processes or plumes (*lp*) as two rounded bosses composed of tissue resembling hypoderm. The buccal disk (*bd*) is cut at its anterior region, but the central space (*bc*) of the organ is well developed. The collar space (*vc*) is comparatively large at this stage, and lies close beneath the nerve-centre; × 350.

Fig. 4. Transverse section of the terminal region of the body-cavity of an older bud than the foregoing, the tip of the alimentary canal (*al*) being left as a thin plate in the centre, and bound dorsally and ventrally by the median mesentery (*ms*). The great longitudinal muscle is cut near the commencement of the pedicle, and already shows the double ventral curvatures so characteristic of the latter; *bt*, basement-tissue; *co*, the body-cavity; × 350.

Fig. 5. Ovum on its escape from the adult; *ec*, egg-capsule; *ov*, ovum proper; *st*, stalk; × 90.

Fig. 6. Outline of another ovum in which the yolk is ovoid, instead of circular as in the former case; × 90.

Figs 1,2,5,6, W.C.M. Figs 3,4, E. Prince del F. Huth, Lith. Edin.

CEPHALODISCUS DODECALOPHUS, Mc I.

PLATE VI.

PLATE VI.

Fig. 1. Longitudinal section of the tip of the pedicle of an adult *Cephalodiscus*, showing the attachment of a young bud just above the terminal surface (which is somewhat sucker-like); *lm*, strands of longitudinal muscles; *hps*, modified hypoderm forming the terminal surface of the pedicle; *gm*, section of a young bud, showing the central chamber (*ch*) continuous with the axis of the pedicle of the adult; × 350.

Fig. 2. Transverse section of an adult *Cephalodiscus* through the region of the mouth (*m*) and ovaries, one pigment-mass (*od*), however, only having been cut. The buccal shield (*bs*) on the right is seen folding over dorsally (*bsp*), so as to run into the tissues at the bases of the plumes (*br*); *g*, grooves at the bases of the lophophoral arms. The notochordal region lies between this letter and *m*, though the notochord is not seen in this section. The mouth is observed at (*m*) and the pharyngeal region with its numerous folds and a gill slit (*gs*), while on the left is a section of the post-oral lamella (*pl*) with its central cavity or chamber; *r*, greatly distended rectum; *od*, pigment of oviduct; *ov*, large, and *ov'*, small ova, with nuclei and nucleoli; × 90.

Fig. 3. Transverse section of the shield and dorsal region in the long axis of the central region of the nervous system (*nc*). The thick coating of hypoderm (*hp*) bounds the latter externally, while internally it rests on the basement-tissue (*bt.*); *bp*, sections apparently of the shield-pores in their progress inwards; *bsm*, radial muscles of the buccal disk or shield; *hs*, hypoderm of shield; *od*, position of the pigment of the oviducts; × 210.

Fig. 4. Transverse section of the same bud as in Pl. V. fig. 4, in the anterior region, so as to strike the commencement of the nerve-centre (*nc*), with the central cavity (*c*). The young plumes are irregularly cut from their variable position, and the sides of the disk fold over into the basal region of the plumes. The large size of the terminal process of the plumes is well seen in the larger organ; × 210.

Fig. 5. Section a little behind the foregoing, giving the nerve-centre (*nc*) in full development, under the thick hypodermic coat (*hp*), while the tip of the anus (*an*) has also been included; *cva*, collar space going to plumes; *bsm*, radial muscles of buccal disk; *c*, region of the notochordal. The plumes are more widely separated in this region, and the young filaments have the form of hypodermic papillæ; × 210.

Fig. 6. A somewhat oblique section through the buccal shield (*bs*) and the post-oral lamella (*pl*) with its central cavity, to which the dotted line goes. Beneath is a collar pore (*cp*), which is, however, indifferently shown in this section. The nerve-centre (*nc*) and a pore (*bp*) leading into the cavity of the shield are also cut, the two body-cavities of the region lying above the former (*nc*) in this view, that is ventrally in nature. The other parts are an ovary (*ov*) and a portion of the pigment-mass of an oviduct (*od*); × 90.

F. Huth. Lith.r Edint.

CEPHALODISCUS DODECALOPHUS, McI.

PLATE VII.

PLATE VII.

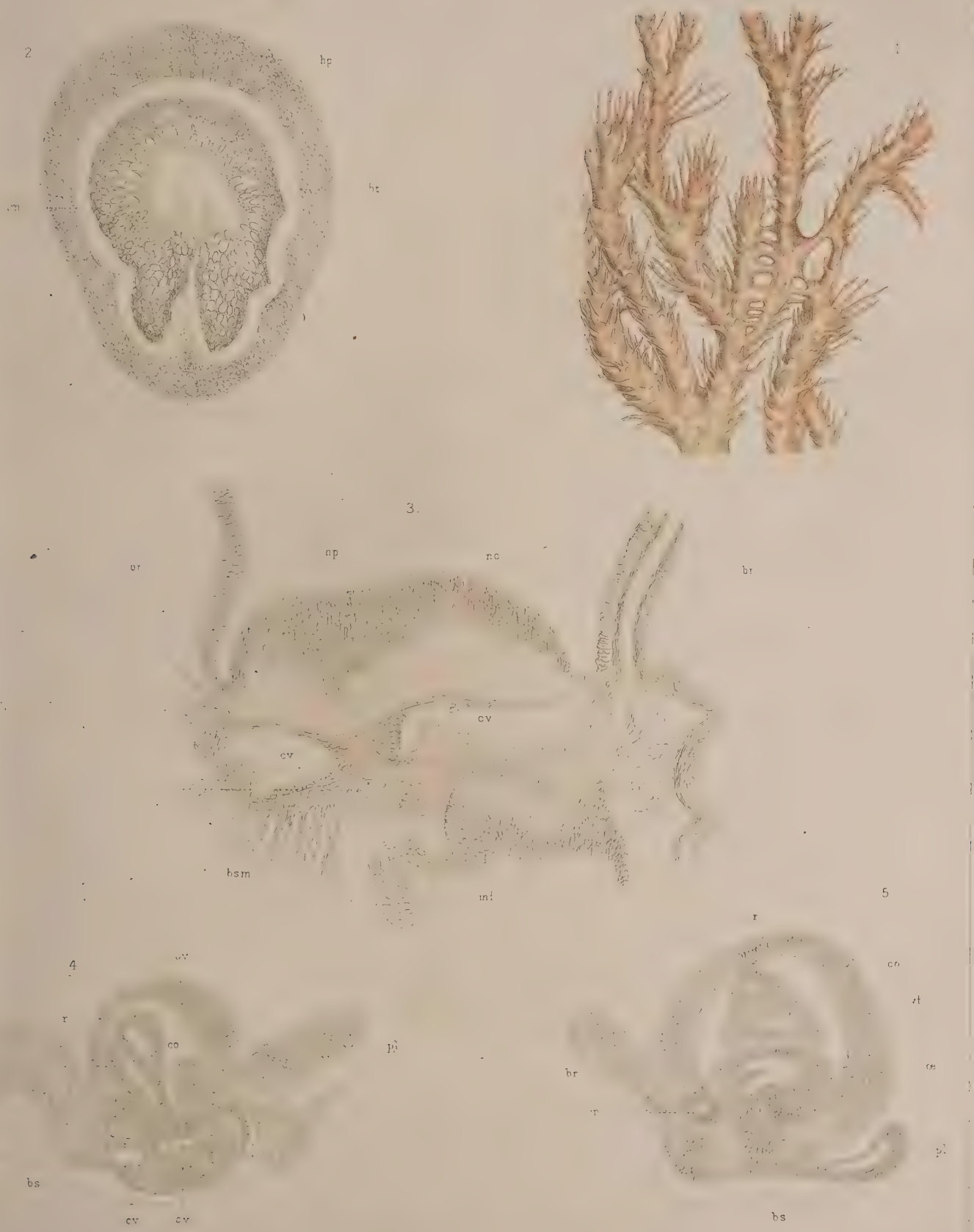
Fig. 1. Portion of the cœnœcium of *Cephalodiscus*, about natural size, tinted as in the spirit-preparations.

Fig. 2. Transverse section of a pedicle of an unstained specimen, showing a somewhat different arrangement of the folds of the basement-tissue and the central muscular fibres; letters as before; × 350.

Fig. 3. Oblique section of the chief area of the nerve-tissue (*nc*), which lies under the thick hypoderm (*hp*) between the plumes (*br*). The collar spaces (*cv*) lie next the basement-tissue, bounding the nerve-centre internally, and a trace apparently of the notochord is observed at *c*. Some of the folds (*mf*) of the mouth have been included in the section, and the radiate muscles (*bsm*) of the buccal shield are observed on the left; × 350.

Fig. 4. Transverse section of the same bud as in Pl. VI. fig. 5, somewhat behind the former. The body-cavity (*co*) now shows the rudimentary generative organs (*ov*), the rectum (*r*), and the œsophagus (*œ*) in section. The collar spaces (*cv*) are distinct, and the post-oral lamella (*pl*) is seen on the right. The position of the buccal shield is indicated by the letters *bs*; × 210.

Fig. 5. Transverse section of the same bud posterior to the former, and the three regions of the alimentary canal now occupy the body-cavity, viz., *r*, the intestine; *vt*, the stomach, while what is probably the pharynx (*œ*) lies ventrally. A collar pore is observed at *cp*; *pl*, post-oral lamella; other letters as before.



W. C. M. & E. Prince del.

F. Huth, Lith^r Edin^r

CEPHALODISCUS DODECALOPHUS, Mc I

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